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FARMERS' BULLETIN 428.

TESTING FARM SEEDS IN THE HOME AND IN THE RURAL SCHOOL.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., October 11, 1910.

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "Testing Farm Seeds in the Home and in the Rural School," by Mr. F. H. Hillman, Assistant Botanist, which has been submitted for publication by Mr. E. Brown, Botanist in Charge of the Seed Laboratory.

Respectfully,

G. H. POWELL,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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TESTING FARM SEEDS IN THE HOME AND IN THE RURAL SCHOOL.

INTRODUCTION.

Progressive farmers who recognize the importance of better and more profitable crop production are becoming convinced that the quality of the seed used is worthy of careful attention.

The results of seed tests made at the Department of Agriculture and at the state experiment stations show that certain kinds of farm seeds in which there is an active trade and a strong competition are often seriously adulterated, the effect being that the farmer buying such seed gains a disappointing experience instead of a satisfactory crop. Again, the seed of certain farm crops is often mixed with seed of especially noxious weeds, necessitating labor and expense in preventing permanent injury to the farm. Seed may have a low germinating power due to age or to unfavorable conditions of development or of harvesting. Seed of clovers and of alfalfa found on the market sometimes comes from foreign regions possessing a less rigorous climate than that under which the seed would be grown in this country. For this reason such seed is undesirable. These results of tests made in the laboratory are fully corroborated by the experiences of farmers engaged in growing crops.

The popular agitation within recent years in the interest of better seed has brought about some change in trade conditions, but much room for improvement still remains. While a few States now have laws pertaining to poor seed, there is no Federal law preventing the importation of poor seed or its distribution by interstate traffic. In consequence of this, protection in seed buying is very largely a matter of business acumen on the part of the individual purchaser, which becomes very important when the purchaser is also the consumer.

In the matter of seed buying the best protection to the purchaser is believed to be self-protection based on the ability to judge the quality of the seed offered. This belief is supported by the fact that it is both possible and practicable for buyers or consumers of seeds to determine very accurately their quality.

The purpose of this bulletin is to encourage seed testing in the farm home and in the rural school by explaining the essential features of seed testing as it relates to farm seeds and by showing how satisfactory tests can be made by simple means. The expense involved is slight and, considering the little effort and time required, is thoroughly justified by the practical information to be gained. The writer's observation of the readiness with which beginners have qualified

themselves for making such tests under instruction scarcely more favorable than that offered here, satisfies him of the absence of any valid reason why farmers should not protect themselves from the use of poor seed.

An important advantage of making tests at home is that the time required to get a report on a sample of seed sent to Washington or to an experiment station for test is saved. This obstacle removed, a practical examination or test will often be made, when if the seed must be sent away it will be bought untested. Furthermore, a purchaser's order from sample is much more likely to be filled from the seed actually represented by the sample if the delay in sending away for a test report is avoided.

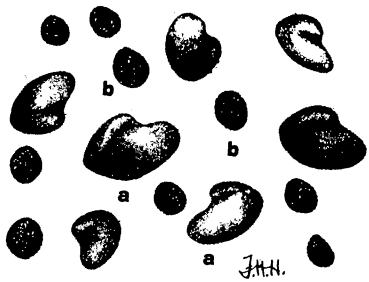

FIG. 1.—Seeds of clover dodder (b) and red clover (a), showing relative sizes. (Enlarged.)

Seed testing is admirably adapted for practical exercise work in rural schools giving instruction in elementary agriculture. It is easily carried on at any season of the year and requires but little outlay for apparatus or working material. If tests are made of seed of interest at the time in the homes of the pupils, the results may be of very practical service. A study of farm seeds and their impurities tends to interest pupils in crops and weeds and in their interrelation on the farm.

SEED TRADE CONDITIONS.

GENERAL STATEMENT.

Most of the undesirable conditions exhibited by seed which make seed testing necessary are the result of trade influences. The responsibility for these conditions doubtless rests fully as much with the mass of consumers who demand low-priced seed as with the dealers who cater to this demand. The trade has employed various means to meet the demand for low-priced seed. Large importations are made of the same kinds of seed which are produced in and are exported from this country. The imported seed can be sold cheaper than that which is exported. Grades of seed which are practically unsalable in Europe find a ready market here because the better American-grown seed is commonly considered too high priced. Various forms of seed adulteration have long been practiced, and seed ill adapted to our climatic conditions has often been sold. The results have been frequent failure of crops, an excessive cost of the actually good seed, and a wider distribution of many kinds of foreign weeds than by any other means. A general understanding of these conditions as they relate to particular kinds of seeds is helpful in making tests.

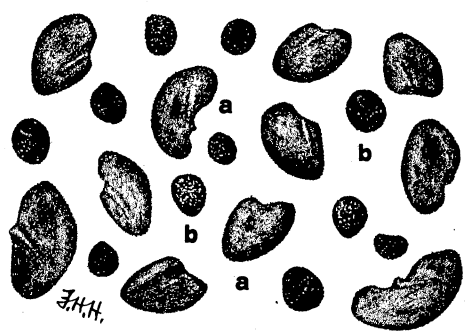

FIG. 2.—Seeds of clover dodder (b) and alfalfa (a), showing relative sizes. (Enlarged.)

APPLICATION TO KINDS OF SEEDS.

Red clover and alfalfa.—Seed of both red clover and alfalfa is imported, chiefly from Europe, in large quantities annually, and much of it is low in quality. Such low-grade seed is usually very weedy. The imported red clover seed is often a grade of small-seeded screenings which carries a class of weed seeds rarely found in a large-seeded grade of clover seed. Such low-grade seed carries seed of clover dodder in nearly every instance, while American-grown clover seed practically never carries this kind of dodder seed. (See fig. 1.) Shriveled alfalfa-seed screenings containing very little, if any, good seed are sometimes imported. Such material can serve only as an adulterant. Cheap imported alfalfa seed usually carries clover dodder while American seed is free from it. (See fig. 2.) Again, buckhorn, wild carrot, and wild chicory seeds are nearly always found in the cheap alfalfa seed from Europe, while they do not appear in most lots of American seed.

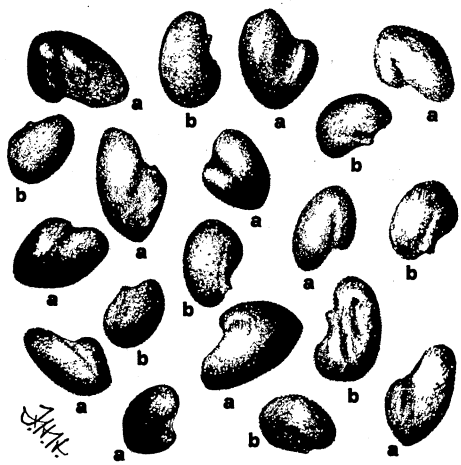

FIG. 3.—Mixture of seeds of red clover (a) and yellow trefoil (b). The clover seeds are more or less triangular, those of trefoil oval, and usually with a distinct projection beside the scar notch. (Enlarged.)

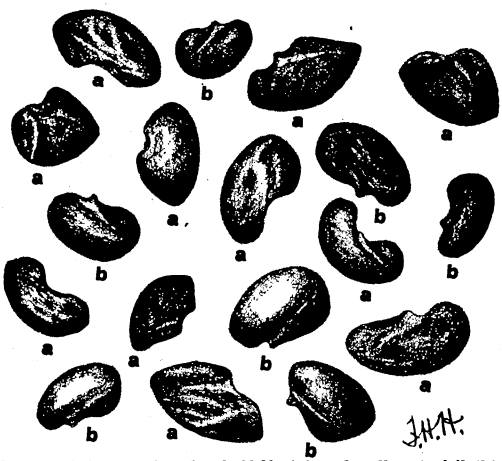

FIG. 4.—Mixture of seeds of alfalfa (a) and yellow trefoil (b). Alfalfa seeds are more or less kidney-shaped or angular, while those of trefoil are more uniformly oval and have the small projection at the scar more commonly evident. (Enlarged.)

Both red clover seed and alfalfa seed are subject to adulteration with yellow trefoil seed. (See figs. 3 and 4.) Alfalfa seed, furthermore, is adulterated with sweet clover seed (fig. 5) and with seed of the bur clovers. (See fig. 6.) Seed of red clover, alfalfa, and crimson clover from the warmer parts of Europe is from a tenderer strain of plants than is demanded in most parts of this country. Experiments have shown that, as a rule, such seed can not compete in crop production with domestic seed.

Considerable red clover seed has been imported from Chile within recent years. This seed is the best appearing clover seed in our market, and authentic reports show that it has proved productive in various localities extending from Canada nearly to the Gulf States.

Nearly every lot of this seed that has come under our observation, however, has been badly infested with an unusually destructive strain of field dodder seed (fig. 7).

Alsike clover.—Seed of alsike clover is produced in the Northern States, but much of that in the market is imported from Canada. Very little is imported from Europe. Canadian seed, and doubtless some of that produced in the United States, often contains much Canada thistle seed — more, indeed, than is found in any other kind of farm seed. Yellow trefoil seed commonly appears in alsike seed, sometimes to the extent of severe adulteration. Low-grade, weedy, and shriveled screenings are sometimes used as an adulterant. (See fig. 8.)

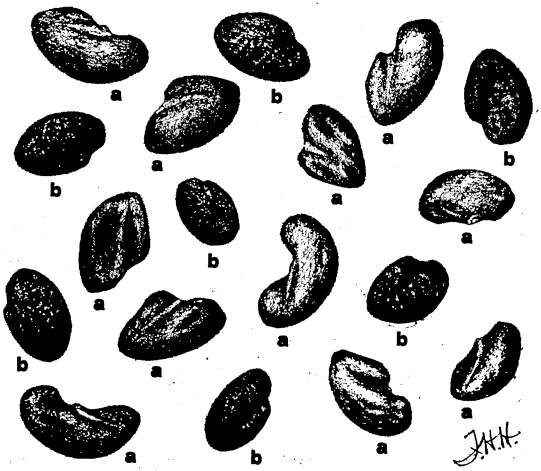

FIG. 5.—Mixture of seeds of alfalfa (a) and sweet clover (b). The elliptical form of the sweet clover seeds, which have the scar notch near one end, together with their uneven surfaces, serves to distinguish them from the more nearly kidney-shaped and smoother alfalfa seeds. (Enlarged.)

Several of the commoner kinds of weed seeds found in alsike clover seed are very detrimental. Some lots of alsike seed consist largely of timothy, which amounts to an adulterant if the mixture is sold at the price of pure alsike seed. This mixture is poor seed to sow if alsike seed production is contemplated; the two crops ripen together and their seed can not be wholly separated.

Old stocks of seed of the clovers and of alfalfa having low vitality are often mixed with new seed. Such seed is sometimes oiled and rubbed to give it the appearance of freshness.

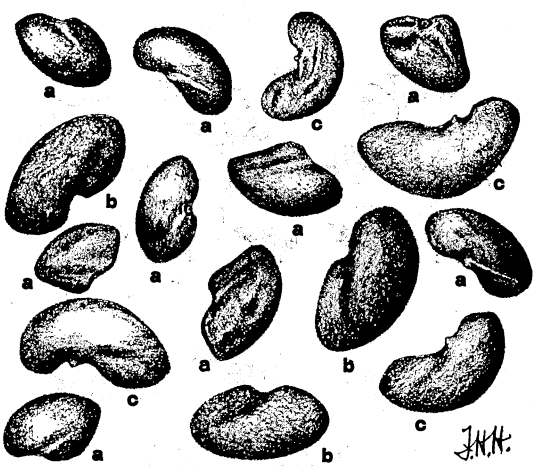

FIG. 6.—Mixture of seeds of alfalfa (a), toothed bur clover (b), and spotted bur clover (c). Note the larger size of the bur clover seeds, also the kidney shape of the spotted bur clover seeds, which have the scar near the smaller end. (Enlarged.)

Grass seeds.—The seeds of grasses are subject to various conditions tending to reduce their quality. Adulteration with old seed or chaff of the same kind or with the very similar appearing seeds of other kinds is often practiced and readily escapes detection by both retail dealers and consumers. Accidental misbranding of grass seed in the trade is doubtless not uncommon.

Kentucky bluegrass seed is often adulterated with the similar Canada bluegrass seed or seed of the latter is substituted for the former. (See fig. 9.) Again, Kentucky bluegrass seed often has low germinating power, owing to improper methods employed in curing, and it is commonly very chaffy.

Orchard grass seed is adulterated with seed of meadow fescue, English rye-grass, or with both. (See fig. 10.)

Seed of meadow fescue, or English bluegrass, is adulterated with seed of the perennial, or English, rye-grass and with orchard grass chaff. (See fig. 10.)

Awnless (or Hungarian) bromegrass (*Bromus inermis*) seed is adulterated with meadow fescue and English rye-grass seeds and with chess, or cheat. (See fig. 11.) The latter has even passed in the trade as Hungarian brome seed.

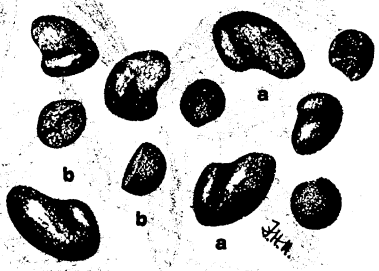

FIG. 7.—Seeds of field dodder (b) and red clover (a), showing relative sizes. (Enlarged.)

Redtop seed appears in the market in three grades, "recleaned" (or "solid"), "unhulled," and "chaff" redtop. The latter is very misleading, since it sometimes contains practically no good seed. The recleaned grade sometimes contains considerable timothy, which is inexcusable unless sold as mixed redtop and timothy.

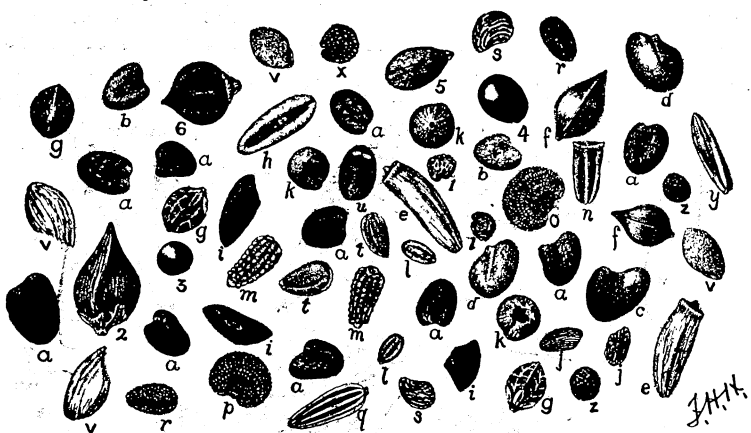

FIG. 8.—Mixture of weed seeds commonly found in low-grade alsike clover seed: **a**, Alsike clover; **b**, white clover; **c**, red clover; **d**, yellow trefoil; **e**, Canada thistle; **f**, dock; **g**, sorrel; **h**, buckhorn; **i**, rat-tail plantain; **k**, lamb's-quarters; **l**, shepherd's-purse; **m**, mayweed; **n**, scentless camomile; **o**, white campion; **p**, night-flowering catchfly; **q**, oxeye daisy; **r**, small-fruited false flax; **s**, cinquefoil; **t**, two kinds of pepergrass; **u**, catmint; **v**, timothy; **x**, chickweed; **y**, Canada bluegrass; **z**, clover dodder; **1**, mouse-ear chickweed; **2**, knot-grass; **3**, tumbling amaranth; **4**, rough amaranth; **5**, healall; **6**, lady's-thumb. (Enlarged.)

Rape, vetch, and flax.—Winter rape seed is liable to contain seed of the summer rape (bird rape), an annual variety of rape not adapted to the forage purposes of the winter rape. Seed of either winter rape or summer rape may contain the seed of various wild mustards, especially that of English mustard, or wild charlock. (See fig. 17, **t**.)

Winter (or hairy) vetch seed often contains seed of various varieties of spring vetch, from which it should be free.

Considerable flax seed is imported from Russia mixed with many impurities, including seed of the flax dodder, a kind of dodder particularly destructive to flax. (See fig. 12.) Seed from certain regions of production in this country is free from this dodder, false flax seed, and other impurities.

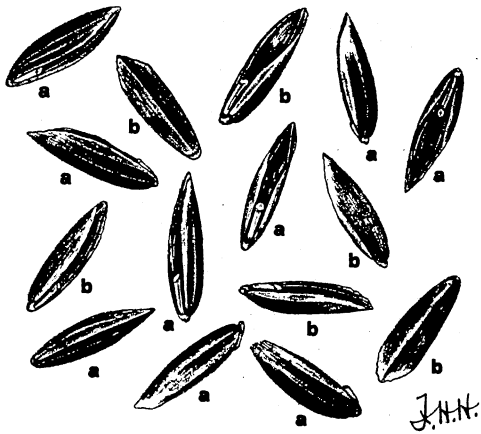

FIG. 9.—Mixture of seeds of Kentucky bluegrass (a) and Canada bluegrass (b). The Kentucky bluegrass seeds are broadest at the center, pointed, and have a distinct ridge on each side. Canada bluegrass seeds are mostly broadest near one end, blunt, and smooth on the sides. (Enlarged.)

APPRECIATION OF GOOD SEED NECESSARY.

These and other conditions of the seed trade operating against the use of the best seed have long prevailed in this country. They are likely to continue, largely irrespective of laws to the contrary, until consumers generally come to appreciate and accept only good seed. Consumers will need to know good seed from poor and to understand that the legitimate price of good seed is actually lower than the corresponding price of poor seed

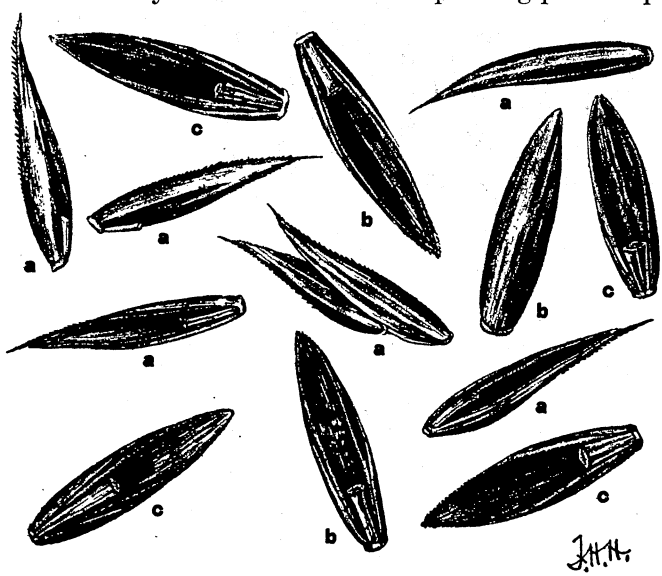

FIG. 10.—Mixture of seeds of orchard grass (a), meadow fescue (b), and English rye-grass (c). The orchard grass seeds are distinguished from the others by their slender, curved form. The meadow fescue and rye-grass seeds are distinguished by the difference in the section of the seed-cluster axis (rachilla segment) which each bears. (Enlarged.)

which costs relatively more to market, although the original cost to the dealer may be lower than that of high-grade seed.

PURPOSE OF SEED TESTS.

The purpose of making tests of farm seed is to detect the undesirable conditions affecting the seed which have been referred to in preceding paragraphs. Such tests should be made early enough in the season to allow ample time to obtain other samples or to buy

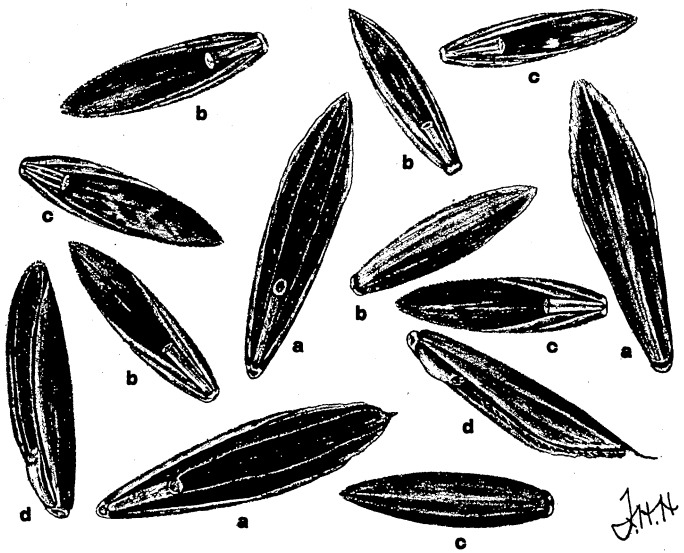

FIG. 11.—Mixture of seeds of awnless brome-grass (a), meadow fescue (b), English rye-grass (c), and chess, or cheat (d). The brome-grass seeds are distinguished by their greater length and flattened form. The seeds of chess (d) are somewhat cylindrical, due to being folded lengthwise. They are thus thicker than the awnless brome-grass seed and sometimes are awned. (Enlarged.)

additional seed if the tests lead merely to providing for foreign matter by sowing a larger quantity of seed.

The seed of most of the farm crops can be recognized with certainty under careful examination as to its particular kind. Seed of different varieties of a kind as a rule can not be distinguished in this way. For example, red clover seed can be distinguished from other seeds, but the medium and mammoth varieties of red clover can not be distinguished by their seeds. Seeds of varieties of individual kinds of plants usually must be grown to insure varietal determination. This is not a part of the usual seed test.

FIG. 12.—Seeds of flax dodder (b double, c single) and of flax (a), showing relative sizes. (Enlarged.)

The first object of the test, excepting with respect to varieties, is to find out if the seed is true to name.

The seed of certain farm crops is rarely free from all impurities. Miscellaneous impurities may appear or some one kind of foreign seed may be present as an adulterant. Old seed of the same kind as the crop seed may constitute an adulterant, a fact which becomes apparent in the germination test.

A second object of the test is to show if the seed has been intentionally adulterated.

The miscellaneous impurities of seeds are classified (1) as inert material incapable of growing, and (2) as foreign seed which may be capable of growing and producing plants.

A third object of the test is to show the relative proportions of comparatively harmless inert material and of possibly noxious foreign seed in the sample.

The foreign seeds in a sample, consisting usually of various kinds of weed seeds, may not amount to much in quantity, but their noxious character may make them very important.

A fourth object of the test is to disclose the presence of especially noxious weed seeds, as dodder, dock, thistle, etc.

A fifth object of the test of seeds in which the region of production is a matter of importance is to show, if possible, by the nature of its impurities, the probable source of the seed or to show if it is a mixture of domestic and foreign-grown seed.

A sixth object is found in the germination test, showing how much of the seed is capable of growing under favorable conditions. The energy with which the seed sprouts is to be considered. With new clover and alfalfa seed the amount of "hard seed," or seed which absorbs moisture slowly and therefore sprouts tardily, is to be noted and allowed for in using the seed.

The objects thus enumerated relate particularly to the seed of miscellaneous forage crops. Interest in the seed of the cereals and corn centers chiefly in the germination test with respect to the extent and character of the sprouting.

SEEDS ESPECIALLY NEEDING TO BE TESTED.

While all kinds of farm seeds may be subjected to a test of one kind or another, the seeds of the crops in most general use and which it is especially desirable to have tested represent the true clovers (as red, alsike, and crimson), alfalfa, certain grasses (as timothy, orchard grass, fescue grass, bluegrass, brome-grass, and the millets), cereals, rape, flax, vetch, and corn. The reason for this selection is that much of the seed of the crops enumerated, except cereals and corn, is imported, and widely variable grades are on the market. The magnitude of the trade in this class of seeds shows that the majority of farmers do not depend on domestic production for the seed they use. It is probable that the prevalence of foreign-grown seed in the market is not generally recognized by farmers in localities where locally grown seed is ordinarily used.

EASE OF MAKING PRACTICAL TESTS.

Seed tests sufficiently accurate to answer all practical purposes can be made by a beginner with a little practice. Certain time-consuming and exacting features of detail in making official tests at Washington or at an experiment station are often unnecessary in making tests for the facts of most practical importance.

By providing the apparatus and following the directions for making tests suggested in the following pages and by using the illustrations

in comparing seeds of different kinds one can soon become sufficiently expert to feel reasonable confidence in his ability to avoid errors of importance.

The younger members of the home circle should find such work comparatively easy to accomplish and interesting as well. The testing of locally grown seed would be assisted by the possession of a correctly named set of the seeds of crops and of weeds prevailing in the vicinity.

When the work is done in the school, samples of seed of local interest and obtainable at the homes of the pupils may be used. This tends to impress the pupils (and their parents as well) with the immediate utility of the work. If suitable seed is not obtainable locally, samples representing different grades can be obtained from dealers. The boys can make the balance here described. Several balances may be made and their efficiency compared. The successful making of such apparatus has a distinct educational value of its own. One pupil may be authorized to procure the magnifiers required; another may be delegated to provide one or more plate germinators or to make the corn-germinating box. Germination tests made in cloth, paper, sand, and soil may be compared, showing the effect of surrounding conditions. Such actual practice makes the pupil do and think and fits him to master corresponding but more complex problems later.

APPARATUS USED IN MAKING TESTS.

The need of apparatus.—Only such apparatus is needed in making practical seed tests as enables one to use a weighed quantity of seed from the sample, to separate the pure seed from the foreign seeds and other impurities, to distinguish the character of the foreign seeds, and to make the germination test.

It is important to use a weighed quantity of seed in the test, because only in this way can one determine the relative quantity or percentage of pure seed as compared with the quantity of the impurities. This requires a balance sufficiently sensitive to be moved by a small weight, such as that of a few clover seeds. This sensitiveness is necessary, because only a small sample of seed can be used in the test. A large sample would require too much time and labor. For this reason only small samples are used in making official tests of seeds.

The absence heretofore of a readily available, effective balance suited to this work doubtless has been the chief bar to the popularizing of farm and rural-school seed testing. Expensive chemical balances are used in making official tests, and the cheaper balances on the market cost from $10 to $35—an expense beyond the reach of the mass of consumers who should profit by practical seed tests.

The balance.—A simple, efficient balance can be made by any boy or girl at all familiar with the use of a few common tools. The general construction is clearly shown in figure 13, to which the letters used in the following description refer:

The balance consists of a hexagonal, or six-sided, pencil (a) notched as nearly as possible in the center and halfway through the lead. Make a rather wide V-shaped notch. Half of a similar pencil is

notched likewise at its center, care being taken that the angle at the apex or "bottom" of the notch is made narrow, straight, and smooth. At this point the balance rests on the small blade of a knife, as shown in the figure. The blade must not bind and the pencils must swing on its edge with the least possible friction. The two pencils are firmly rubber-banded together so that the two notches form an opening nearly square between the pencils. Near each end of the long pencil and on its notched side make a shallow hole (c) by boring into

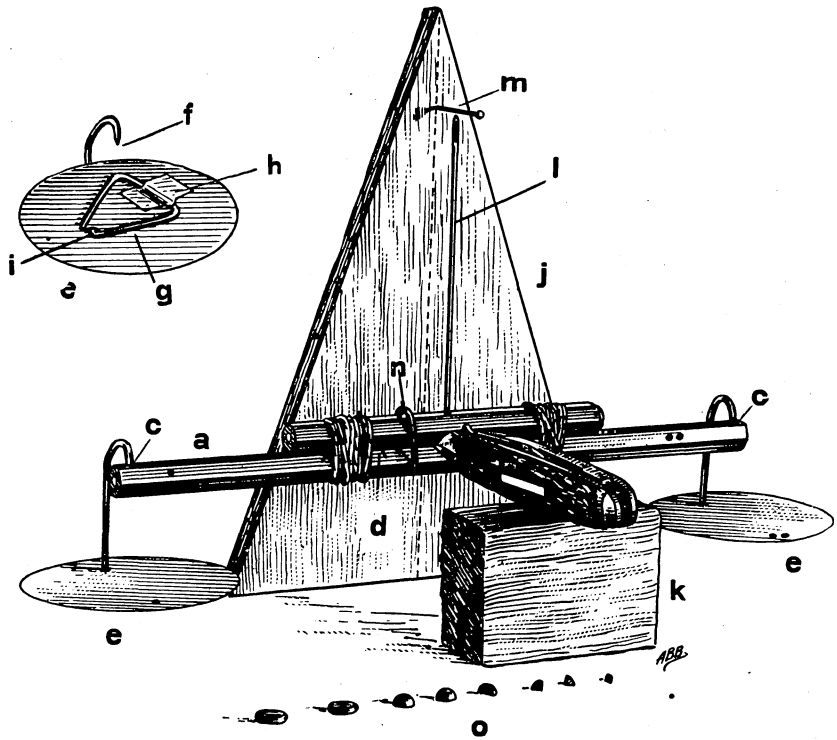

FIG. 13.—A simple balance used in making the purity test of seeds: **a**, Six-sided pencil, full length, and a half-length pencil bound to the long pencil by rubber bands; **c**, shallow holes near the ends of the long pencil; **d**, reference mark common to both pencils at a convenient point on the line where they meet; **e**, trays for holding the seed and the weights, the upper one showing the under side; **f**, bluntly pointed end of the wire adapted to fit loosely in one of the holes (c); **g**, wire bent beneath the tray to hold it in position; **h**, piece of gummed paper holding the wire to the tray; **i**, hole at proper distance from the center of the tray where the wire pierces it; **j**, thin piece of board holding the parts of the balance in position; **k**, the block of wood holding the knife handle at proper level; **l**, darning needle serving as a pointer as the pencils oscillate in weighing; **m**, pin marking the position of the head of the needle when the trays are properly balanced before and at the close of weighing; **n**, "rider," or wire staple, so placed as to balance the trays when empty; **o**, series of selected BB shots used as weights; whole ones are flattened to prevent rolling; others are cut into halves, quarters, eighths, and sixteenths, and selected with reference to the equality of their weights.

the wood with a hard pencil having a smooth, slightly blunt point. In order that the balance may operate properly the apex of the notch in the short pencil—that is, the point which rests on the knife-edge—must be exactly midway between the holes in the ends of the long pencil. Slide the short pencil along the other till it is in proper position, then with the point of the knife-blade cut a mark (d) common to both pencils on the line where they touch. The rubber bands should prevent the pencils from slipping when in use, but the mark

will show if they do slip. Two similar trays (e) are hung from the ends of the long pencil. They consist of circular pieces of stiffish cardboard about 2 inches in diameter suspended by means of wires curved in fishhook form, the points of the hooks resting within the holes (c) previously made in the pencil ends. The points of the hooks (f) are bluntly and smoothly pointed, so as not to bind in the holes. Beneath the trays the wires (g) are bent to hold the trays in level position, and are held to the tray by pieces of gummed paper (h). The illustration shows the trays as flat pieces of cardboard. It is better to cut the trays from the edge to the center, then lap the two cut edges and glue them fast, thus making a shallow dish. The wire (g) beneath the tray is then preferably bent in circular form. Balancing the tray hook on the finger shows the proper bending of the wire where it pierces the cardboard (i) to make the tray hang level. A triangular piece of thin board (j), as a cigar-box cover, serves to hold the knife blade in position. A block (k) holds the knife handle. The knife is set high enough to permit the trays to hang about one-half inch above the surface on which the balance rests. For the purpose of showing slight movements of the balance in exact weighing, a darning needle (l) is set in the top of the short pencil directly over the knife-edge and at right angles to the pencil. A pin (m) is placed in the board directly over the point where the knife point pierces it and just above the end of the needle. When the device is properly balanced the end of the needle will stand at rest directly under the pin. It probably will not balance until a staple of wire (n) is placed over the pencils in proper position on one side of the knife blade or on the other as a counterweight. This completes the construction, and when properly mounted the balance should oscillate freely by the slightest touch. As the trays are likely to be interchanged in use it is advisable to mark each, placing corresponding marks on the ends of the pencil at which the trays preferably belong.

In making seed tests we may use common BB shots (whole and fractional) for weights. This is because we wish to know only the comparative weights of the pure seed and of the foreign seed and other impurities in the sample. Thus if we test an amount of seed, balancing ten shots, and find that the weed seeds it contains just balance one shot, it is evident that one-tenth of the original seed, or 10 per cent, consists of impurities. In other words, 90 per cent (or 90 pounds of each 100 pounds) of the original seed is pure seed. In using a balance so sensitive as the one described a single BB shot is too heavy for use as the lightest weight. We need a weight to be balanced by only a few clover seeds at most. Very small shot is troublesome to handle and count, so we use the larger BB shots, flattening the whole ones to prevent them from rolling, and cutting some into halves, quarters, eighths, and sixteenths. By careful selection according to weight a fairly uniform series (o) of whole and fractional shots can be provided. Now, the weight of one-sixteenth shot is 1 per cent of the weight of $6\frac{1}{4}$ shots, because $6\frac{1}{4}$ equals $100 \div 16$. So if we test a sample of seed balancing $6\frac{1}{4}$ shots any impurity balancing the $\frac{1}{16}$-shot weight represents 1 per cent of the sample tested. If the sample is twice as heavy, balancing $12\frac{1}{2}$ shots, the $\frac{1}{16}$-shot weight represents one-half of 1 per cent of the whole.

It is evident, therefore, that the means described enables one to determine the quantity of pure seed or of impurities in a sample to

within 1 per cent, or even one-half of 1 per cent of the true quantity. This is sufficiently close for the practical seed testing under discussion.

The forceps.—A pair of forceps is very useful in picking up the small weights used with the balance, also individual seeds. Suitable forceps may be made of two thin pieces of hickory wood separated by a piece of wood to which one end of each piece is fastened. The free ends are flattened and pointed. A piece of spring wire bent in U shape and having flattened and pointed ends serves very well as forceps.

The magnifiers.—After the seed to be tested has been properly weighed it is to be separated into pure seed and foreign seed or other impurities. This requires a magnifier. Very coarse seed—such as that of wheat, oats, flax, etc.—can usually be examined by the aid of an ordinary reading glass, which is to be found in many homes or can be bought at a cost of $1 to $2. Clover seed, alfalfa seed, and the grass seeds require a magnifier of higher power. A very satisfactory magnifier of this kind is the tripod magnifier, shown in figure 14. With it one can distinguish all the kinds of crop seeds and practically all the different kinds of adulterants and weed seeds. This magnifier is sold by opticians, stationers, and druggists generally throughout the country at prices ranging from 50 to 75 cents.

FIG. 14.—Magnifying glass.

The paper tray.—Seed is examined best over white paper, and in order to prevent the loss of seed from a weighed sample a paper tray is useful. Such a tray is made from stiffish white paper, as a sheet of heavy letter paper. The edges of the sheet on all four sides should be folded over, making a rim one-fourth inch wide. Folding the edges over the straight angular edge of some convenient object largely prevents the paper from warping and makes it easier to use. Cutting off one corner permits the seed to be poured easily from the tray.

The germinator.—Figure 15, showing the simple plate germinator, is self-explanatory. Either blotting paper or cloth may be used to receive the seed. Clean sand may be preferable for some kinds of seed. A germinator of this description is most useful in testing forage-crop seeds or seeds of cereals. In testing corn the sand-box method, described in Farmers' Bulletin 409, entitled "School Lessons on Corn," is very satisfactory, or the cloth method may be employed. This method makes use of a box of convenient size, say 20 inches square, interior dimensions, and 2 or 3 inches deep. The seed is placed on white cloth, preferably Canton flannel, which is cross marked on the smooth side with distinct pencil lines in 2-inch squares. The required moisture is held by extra thicknesses of cloth or by clean sand beneath the cloth, forming a layer about an inch

thick over the bottom of the box. If Canton flannel (which comes 27 inches wide) is to be used instead of sand, the box may be made narrower than suggested, say 12 inches, thus allowing for folding the cloth and for shrinkage.

DISTINGUISHING CHARACTERS OF SEEDS.

Safeguarding against deception.—One of the first steps in testing seeds of the forage crops is to determine if the sample is true to name, and it is necessary that these kinds of seeds be recognized with certainty. While most farmers, as a rule, can recognize red clover seed, for example, when they see it in bulk, it is not so certain that they would recognize individual seeds of red clover under all conditions, as one must in making tests of this seed. Again, alfalfa seed in bulk is recognized by most farmers, because they contrast it with red, alsike, and white clover seed with which they are familiar as these seeds appear in bulk. It is a question, however, if the average farmer would detect yellow trefoil seed in bulk or sweet clover seed in bulk were it not for the characteristic odor of the latter. Bur clover seed would be found even more deceiving.

The chances for deception are even greater with grass seeds than with clover seeds, because of the striking similarity between the seeds of different kinds when seen in bulk. This similarity and the fact that mere casual examination is usually given seed by purchasers makes adulteration, substitution, and misbranding possible.

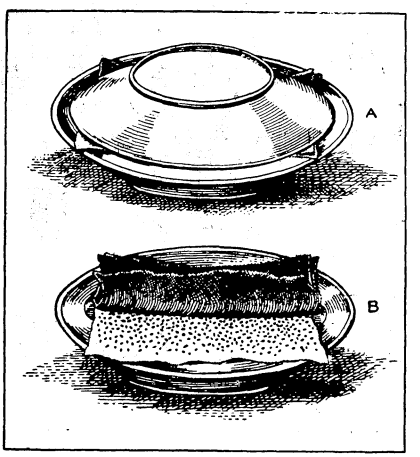

FIG. 15.—Homemade seed germinator: A, Closed; B, open.

The remedy lies in familiarity with the distinguishing characters of individual seeds. By comparing seeds of the several kinds with the illustrations and descriptions here given one should be able to distinguish them individually without much difficulty.

Leguminous seeds.—All the true clovers (as red, alsike, white, and crimson), alfalfa, the vetches, trefoil, sweet clover, and bur clover, produce seeds in a pod which (except in trefoil, sweet clover, and bur clover) opens at maturity. In red clover, trefoil, and sweet clover a single seed is produced in each pod. Consequently, the seeds of each kind are very similar in form. (See figs. 22, 23, and 27.) Alfalfa and bur clover produce several seeds in a spiral pod, resulting in considerable variation in the form and size of individual seeds. (See figs. 6 and 26.) Seeds of the true clovers, alfalfa, trefoil, bur clovers, and sweet clover are more or less flattened and (excepting crimson clover) are notched in the edge. Within this notch the seed scar, or point of attachment to the plant, appears as a small but distinct ring. (See figs. 22 and 26.) In the more or less spherical seeds of the vetches the scar is an oval, wedge-shaped,

or slender spot on the curved surface. (See fig. 32.) In this class of seeds the scar is an important mark of distinction. In several of the small-seeded kinds of leguminous plants occasional pods appear even in well-cleaned lots of seed. (See figs. 22, 23, and 27.)

Most of the grass seeds, also oats and barley, appear "in the chaff," that is, the grains or kernels of the seed, illustrated by the kernels of wheat and the hulled seeds of timothy, are usually covered by the dried chaffy flower scales. (See fig. 16.) The difference in size, form, and structure of this chaff marks the different kinds of grass seeds.

Seeds of the grasses.—Grass seeds are produced in clusters (spikelets). Some clusters contain several seeds arranged along a common axis (rachilla). At maturity the clusters break apart, each seed carrying a piece of the cluster axis (rachilla segment). Such seeds have two chaff scales, one (the lemma) larger than the other (the palet or palea). (See fig. 16.) Examples of this class of grass seeds are found in orchard grass, meadow fescue, rye-grass, brome-grass, and in the bluegrasses. (See figs. 10 and 9.) In another class of grasses each cluster contains but a single seed which, therefore, has no rachilla segment. The seeds of broom-corn (or grain) millet are a good example of this class, the seed scales, lemma, and palea being hard, smooth, and shining. (See fig. 31, **a**.) Part of the seed of foxtail millet, Japanese millet, and the foxtail weeds differs structurally from the last only in being covered by two or three additional chaffy scales, which constitute the "outer chaff." (See fig. 31, **b** and **c**.)

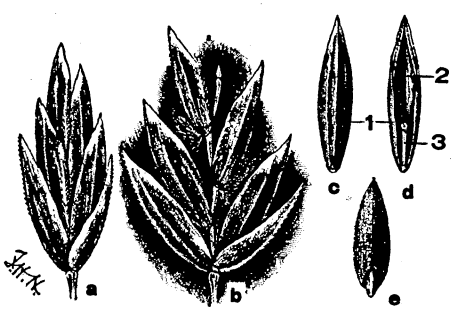

FIG. 16.—A spikelet and florets ("seeds") of Kentucky bluegrass: **a**, Spikelet as it appears at maturity; **b**, the same having the florets spread apart, showing the jointed rachilla; **c**, back view of a floret, showing the lemma (1); **d**, front view of the floret, showing the edges of the lemma (1), the palet (2), and the rachilla segment (3); **e**, the grain or kernel of the seed.

These features of form and structure are easily recognized when representative seeds come to be compared under a magnifier, and it is advisable to understand them in making tests of clover and grass seeds, because the element of certainty is essential to satisfactory results.

IMPURITIES OF FARM SEEDS.

CLASSIFICATION.

The impurities carried by farm seeds have an important bearing on the real quality of the seed. Their quantity may be sufficient to unduly increase the cost of the good seed and their character may be that of injurious weeds.

Seed impurities are classified (1) as inert material and (2) as foreign seed, including both other crop seed and weed seeds.

INERT MATERIAL.

The inert material constitutes essentially such impurities as will not grow (exclusive of dead seed), as chaff, empty seed hulls, broken seed, pieces of stems and leaves, sand, dust, etc. The chief objection to such material is that it replaces good seed, thus increasing the cost. In grass seed the inert chaff misleads by causing the seed to present a better appearance than its quality justifies, as in bluegrass seed and chaff redtop seed. As compared with weed seeds, inert material is of minor importance, a fact not to be overlooked in the purchase and use of seed. The practical seed test should point out clearly the relative importance of the inert matter and of the weed seeds found in the sample.

OTHER CROP SEEDS.

Seed of various farm crops sometimes constitutes a part of the foreign seed. Its proportion as compared with the weed seed should be noted in making the purity test. The importance to be attached to the occurrence of such crop seed depends on its nature; for illustration, the presence of timothy seed is detrimental to alsike clover seed used with a view to alsike seed production, while for hay production a mixture of timothy and alsike seed often is preferable.

WEED-SEED IMPURITIES.

Quantity and Kinds of Weed Seeds.

Very few samples of forage-crop seeds are found wholly free from weed seeds. The methods of culture and of harvesting in vogue operate against a pure seed crop. The proportion of the weed seeds appearing incidentally in the marketed seed is dependent on the number and character of the weeds in the seed-producing crop and the extent to which the seed has been cleaned before being marketed.

Weed seeds occurring in farm seed are of interest to the buyer of seed (1) in respect to their total quantity and (2) in respect to their kinds. In many instances low-grade seed contains so much weed seed that the quantity of the crop seed is thereby greatly reduced in a given weight of seed. Of the kinds of weed seeds 300 to 400 are known to occur in the various kinds of the common crop seeds. Occasionally from 75 to 100 kinds of weed seeds are to be found in a single sample of red clover or alfalfa seed not exceeding a few ounces in weight. In some instances one or more kinds of weed seed are very abundant in the sample. As a rule, however, most of the kinds are represented by only a few seeds.

The important question in regard to the kinds of weed seeds found in crop seed is whether the plants they produce are injurious or relatively unimportant. Some of the weed seeds commonly found in seed produce plants which are very detrimental to the crop or to the land. Everyone making tests of seed should become familiar with the seeds of injurious weeds. Most of the weed seeds found in making tests are seeds of comparatively harmless plants, and their recognition as to kind becomes more a matter of interest than one of practical importance.

Certain kinds of crop seeds, as clover, alfalfa, awnless brome-grass, etc., are supplied to the American market from both foreign and domestic sources. Since domestic seed is generally preferable to that which is imported, the source of the seed as indicated by the weed seeds it contains gives an added interest to some kinds of weed seeds. Thus the presence of seeds of perhaps several kinds of native weeds in a sample of clover seed or of alfalfa seed, together with the absence of seeds commonly found in imported seed, practically amounts to proof of its domestic production. Foreign production is strongly suggested by reverse conditions. Many kinds of weed seeds found in imported seed grow and produce plants in this country, it is true, but the growth or seed production of the plants is so meager or is so restricted to certain localities that their seeds rarely or never appear in the American-grown seed crop. When such seeds appear as several kinds together, or in abundance, they practically prove the foreign origin of the seed containing them.

The illustrations of weed seeds presented here show the seeds classified (1) as noxious weed seeds found in farm seeds (figs. 17 and 18) and (2) as other weed seeds commonly found in farm seeds (figs. 19, 20, and 21). The figures, together with the brief descriptions of distinguishing characters, should enable one readily to recognize these seeds when examined with a magnifier. Weed seeds that are found with the several kinds of clover, grass, and cereal seeds are mentioned under the subsequent discussion of the testing of these crop seeds.

Noxious Weed Seeds Found in Farm Seeds.

The following brief descriptions point out the most conspicuous distinctions between the seeds of various noxious weeds. They only supplement the illustrations to which they refer and which show the general form and structure and the natural size of the seeds. The serial order is employed for ready reference in the subsequent discussion of testing particular kinds of seeds.

The seeds of sand bur (fig. 17, **a**) have somewhat the appearance of small wheat kernels, usually light brown or straw colored; common in alfalfa seed from the Great Basin region. The spiny burs of this grass reduce the feeding quality of alfalfa hay.

The seeds of wild oats (fig. 17, **b**) are similar to seeds of cultivated oats, but always have a twisted and bent, brown or straw-colored awn (sometimes broken away) from near the middle, a tuft of light-brown hairs on the rachilla segment and about the characteristic, cup-shaped rim of the scar at the base of the seed; widely distributed and common in seeds of cereals (especially oats) and large-seeded grasses.

Chess (or cheat) seeds (fig. 17, **c**) are straw colored, sometimes greenish or brown when in the chaff (as figured), the awn at the apex often broken away, the club-shaped form of the rachilla segment distinguishing this from cultivated grass seeds; common in seeds of cereals and large-seeded grasses generally; the reddish-brown, trough-shaped free grains sometimes appear in clover seed.

Darnel seeds (fig. 17, **d**) are robust, straw colored, and in the absence of the slender awn somewhat resemble large seeds of meadow fescue and English rye-grass; common in seed of cereals, particularly wheat.

Quack (or couch) grass seeds (fig. 17, **e**) closely resembles fescue and rye-grass seeds, but they are usually slenderer, light (or yellowish), sometimes greenish colored; whole spikelets having the two empty scales noticeably joined at the same level at the base of the spikelet (thus differing from most grass spikelets) are invariably found with the individual seeds. Commonly found in seeds of cereals and the coarse grasses, especially in the seed of awnless brome-grass imported from Europe.

Dock seeds (fig. 17, **f**) are sharply 3-angled, reddish brown, smooth, and shining; one of the commonest of the weed seeds of farm seeds generally, the reddish-brown

ripened flowers (shown at the right of the figure) commonly appearing in seeds of cereals and coarse grasses. Several kinds of dock seeds occur in farm seeds, the commonest being that of curled dock (figured). The similar seeds of broad-leaved (or bitter) dock are sometimes found. Another kind having smaller seeds which are rounded instead of pointed at the base occurs in Chilean red clover seed.

Black bindweed seeds (fig. 17, **g**) are coarse, 3-angled, black when the outer covering

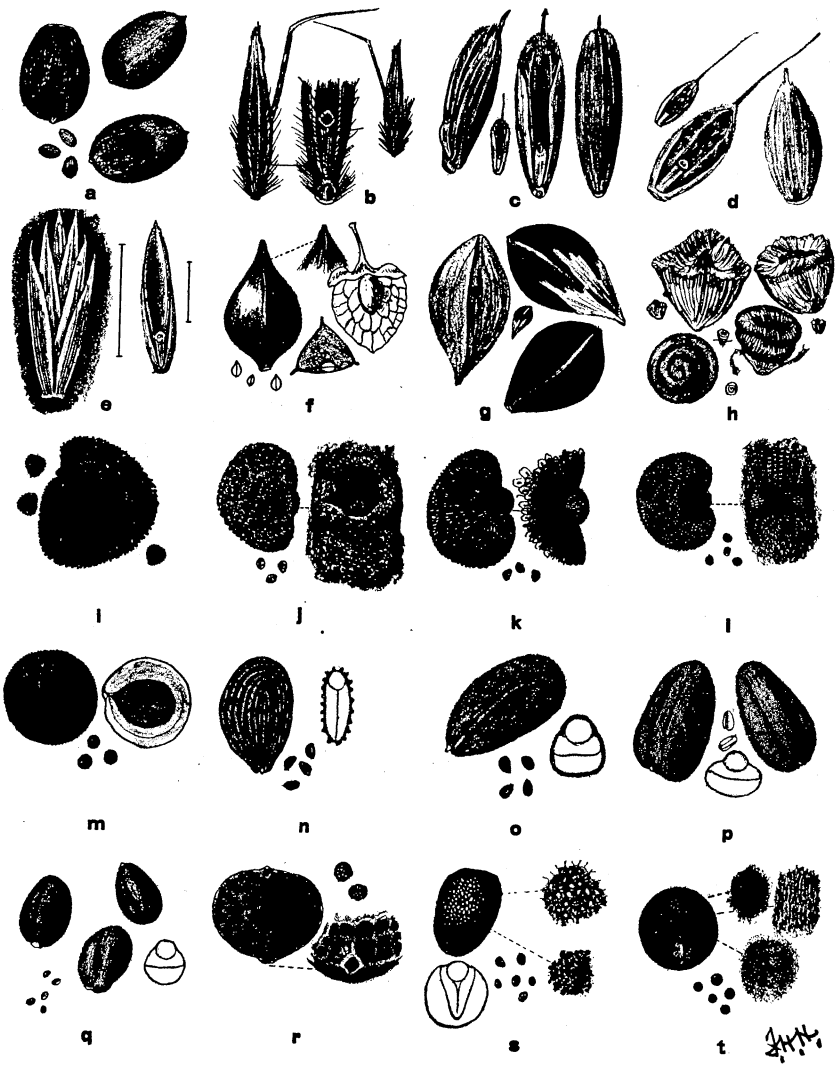

FIG. 17.—Noxious weed seeds found in farm seeds (No. 1): **a**, Sand bur; **b**, wild oat; **c**, chess: **d**, darnel; **e**, quack-grass; **f**, dock; **g**, black bindweed; **h**, Russian thistle; **i**, corn cockle; **j**, white campion; **k**, bladder campion; **l**, night-flowering catchfly; **m**, cow cockle; **n**, pennycress; **o**, field peppergrass; **p**, large-fruited false flax; **q**, small-fruited false flax; **r**, ball mustard; **s**, black mustard; **t**, English charlock. (Enlarged and natural size.)

is removed; the outer straw-colored, greenish, or brown covering (flower scales) may be present or partly or wholly broken away; common in all kinds of coarse farm seeds from all sources, particularly in seed of cereals, millet, and flax.

Russian thistle seeds (fig. 17, **h**) occur both with and without the gray or light-brown hull (flower scales); the seeds proper have a thin coat covering the slender spirally

coiled, greenish embryo; common in alfalfa seed from the Western States and in flaxseed; doubtless occasionally introduced in seed from Russia. As an impurity of alfalfa seed it strongly suggests Western States production.

The seeds of corn cockle (fig. 17, **i**) are black or brown, angular, and covered with fine spiny tubercles; common in seed of cereals, millets, vetches, and flax from all sources.

White campion seeds (fig. 17, **j**) are mostly light gray, the surface finely tubercled, the light color distinguishing this kind from the next two; common in imported crimson clover and grass seeds; sometimes found in red clover seed.

Bladder campion seeds (fig. 17, **k**) are brown or nearly black, flattened, finely tubercled, the tubercles arranged in more or less distinct rows on the sides and in more distinct rows on the edges; occurs frequently in imported grass seed and is sometimes abundant in seed of red and alsike clovers grown in the Northern States and in Canada.

Night-flowering catchfly seeds (fig. 17, **l**) are similar to the preceding, dark gray or brown, finely tubercled, the tubercles not in distinct rows on the sides; very common and often abundant in seed of red and alsike clovers grown in the Northern States and in Canada. Careful comparison of seeds with the illustrations (fig. 17, **j**, **k**, and **l**; fig. 19, **t**) will enable one to distinguish the similar seeds of this group of weeds. Figure 19, **t**, shows the seed of the forked catchfly, which is common in low-grade European red clover and alfalfa seed.

The seeds of cow cockle (fig. 17, **m**) are almost perfectly spherical, black, the surface covered with fine tubercular points; very common in seeds of cereals from the West and Northwest; also in millet and flax seeds, sometimes in imported coarse seeds; broken seeds often occur in alfalfa seed from the Western States, thus indicating its source.

Pennycress (or Frenchweed) seeds (fig. 17, **n**) are oval, flattened, brown, and have concentric ridges on the sides; often found in both domestic and imported seed of cereals, clovers, millets, and flax. This is a dreaded weed in the Northwestern States.

Field peppergrass seeds (fig. 17, **o**) are reddish brown, oval, smooth, and show a curved line on each side; common in domestic and imported seed of various clovers, grasses, and cereals.

False flax seeds (fig. 17, **p** and **q**) as found in farm seeds represent two kinds of false flax (plants in no way related to the true flax). Seeds of the large-fruited false flax (fig. 17, **p**) are light yellow and much larger than those of the other kind; very common in flax seed (hence the common name); also, in millet and sometimes in alfalfa seed; common in coarse farm seeds from Russia. Seeds of small-fruited false flax (fig. 17, **q**) are much smaller than the others, and darker, being reddish yellow; common in Canadian red and alsike clovers and timothy seed.

Ball mustard seeds (fig. 17, **r**) are unopened, straw-colored, brown or purplish pods, having a network of ridges over the surface and containing a single yellowish seed within; found in seed of cereals, millets, and flax; sometimes in imported seed. This is a troublesome weed in certain sections of the Northern States.

Black mustard seeds (fig. 17, **s**) are small, commonly somewhat oblong, and reddish brown or dark brown, sometimes gray, surface pitted, due to a network of ridges; taste distinctly pungent; sometimes found in clover and grass seeds.

English charlock, or wild mustard, seeds (fig. 17, **t**) are almost spherical, slightly variable in size, black, reddish brown, or sometimes light brown, the surface comparatively smooth, which distinguishes this seed from seed of other mustards and rape; taste somewhat pungent; a frequent impurity of nearly all the common clover, grass, and cereal seeds; sometimes an adulterant of rape seed.

Indian (or brown) mustard seeds (fig. 18, **a**) are oblong-spherical, averaging larger than those of charlock, light-reddish brown, the surface having a distinct network of fine ridges; taste not pungent; occurring chiefly in seeds of cereals, millets, and flax; common in imported flax seed; sometimes mixed with rape seed.

Hare's-ear mustard seeds (fig. 18, **b**) are oblong, surface granular, dark brown, and if placed in water develop mucilage which forms whitish projecting points over the surface on drying; common in seed of cereals, millets, and flax; often in imported seed. This is an objectionable weed of the Northern States.

Tumbling mustard seeds (fig. 18, **c**) are very small, flattened, oblong, and yellowish, often with a greenish line along the side; found in clover and flax seed from the Northwest.

Wild carrot seeds (fig. 18, **d**) are light brown, oval, flattened, nearly plane on one side and ridged lengthwise on the other, the ridges often bearing the remnants of whitish spines; common in red clover and in imported alfalfa seeds, sometimes found in grass seed.

Field bindweed seeds (fig. 18, e) are coarse, oval, rounded on one side and angular on the other, gray, owing to numerous light-colored raised spots on the surface; common in seeds of cereals, in flax, and in other coarse seeds.

Seeds of the dodders (fig. 18, f–j) as a group are recognized by their dull, finely roughened surface, together with their rounded or angular form and their small size.

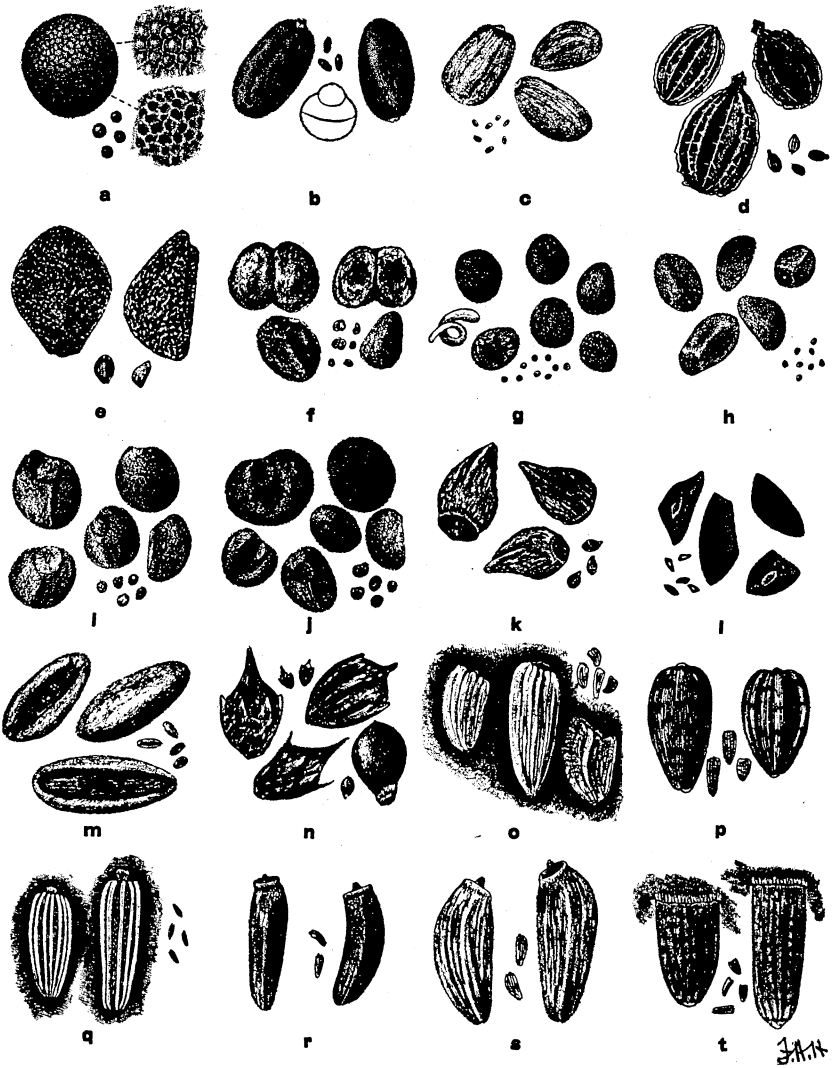

FIG. 18.—Noxious weed seeds found in farm seeds (No. 2): **a**, Indian mustard; **b**, hare's-ear mustard; **c**, tumbling mustard; **d**, wild carrot; **e**, field bindweed; **f**, flax dodder; **g**, clover dodder; **h**, small-seeded alfalfa dodder; **i**, field dodder; **j**, large-seeded alfalfa dodder; **k**, corn gromwell; **l**, rat-tail plantain; **m**, buckhorn; **n**, ragweed; **o**, gumweed; **p**, wild sunflower; **q**, oxeye daisy; **r**, Canada thistle; **s**, bull thistle; **t**, wild chicory. (Enlarged and natural size.)

The slender spirally coiled embryo of the seed, devoid of two cotyledons, is characteristic of dodder seed.[a]

Flax dodder seeds (fig. 18, f) are rounded on one side and angular on the other, many of the seeds united together in pairs; soiled gray in color; found only in flax seed; common in imported seed and in some domestic seed. (See fig. 12.)

[a] See Farmers' Bulletin 306, "Dodder in Relation to Farm Seeds."

Clover dodder seeds (fig. 18, **g**) are very small, nearly spherical as a rule, gray or brown; often distinctly pitted; common in imported clover and alfalfa seeds; not found in grass seed. (See figs. 1 and 2.)

Small-seeded alfalfa dodder seeds (fig. 18, **h**) are similar in size to seeds of clover dodder, but are more oval and angular in form; colors yellowish, greenish, or purplish; common in alfalfa seeds from the Western States. Of the dodders infesting alfalfa this is the most widely distributed within the United States. Its seed is not found in red clover or grass seeds.

The seed of clover dodder and small-seeded alfalfa dodder are sufficiently small to admit of being wholly removed from clover or alfalfa seed of good grade by the use of a sieve of proper mesh (about 20 to the inch). Clover dodder is a menace in any part of the country. Small-seeded alfalfa dodder appears to be naturally confined to the dry regions of the West.

Field dodder seeds (fig. 18, **i**) are larger than those of clover or small-seeded alfalfa dodder, rounded on one face and flattened and angular on the other; the characteristic seed scar is a more or less distinct, circular area having a short, raised whitish line in its center; seeds from the Great Basin region gray or pinkish, those from Chile (evident in Chilean red clover and alfalfa seed) reddish brown; found in both red clover and alfalfa seed, commonest in western-grown alfalfa seed and in Chilean red clover and alfalfa. The plants are very destructive to clover and alfalfa.

Large-seeded alfalfa dodder seeds (fig. 18, **j**), the largest of the dodders found in alfalfa, are variable in size; some are not larger than and are similar to the seeds of field dodder; the largest are nearly circular, rounded, and flattened; color gray, greenish, or more commonly brown; scar devoid of the raised whitish line to be seen in field dodder and often indistinct; found only in alfalfa seed produced in the Western States. This dodder does not appear to thrive in the Eastern States. Field dodder and large-seeded alfalfa dodder are termed large seeded because their seeds can not be wholly removed from clover and alfalfa seed. The greater part of the field dodder can be removed by the use of a sieve of 20 meshes to the inch.

Corn gromwell seeds (fig. 18, **k**) are oval, gray, or brown, and being very hard the name "stoneseed" is often applied to them; found in seed of red and crimson clovers, alfalfa, cereals, grasses, etc.

Rat-tail plantain seeds (fig. 18, **l**) are small, flat, angular, and black; the scar in the center of one side; common in seed of clovers and some grasses. Known also as broad-leaved plantain and as Rugel's plantain; a persistent weed.

Buckhorn seeds (fig. 18, **m**) are smooth, shining, rounded on one side with a deep groove on the other, brown or amber colored, becoming coated with mucilage when placed in water;[a] one of the commonest impurities of farm seeds, often very abundant in seed imported from Europe. Not abundant in alfalfa seed produced in the Western States. Known also as plantain, English or narrow-leaved plantain, and rib-grass.

Ragweed seeds (fig. 18, **n**) as they commonly occur are somewhat top shaped, usually with a crown of several teeth or spines; the outer covering is often broken away, the seed then appearing pear shaped, smooth, and brown; common in American red clover and in cereal grain.

Gumweed seeds (fig. 18, **o**) are whitish or straw colored, variable in form, sometimes wrinkled; found chiefly in alfalfa seed from the Western States.

Wild sunflower seeds (fig. 18, **p**) have the form and the striped, mottled appearance familiar in the cultivated sunflower seeds, but are much smaller; common in alfalfa seed and other seeds from the Western States.

Oxeye daisy seeds (fig. 18, **q**) are very small, but are readily distinguished by the 10 slender, white ridges which extend from end to end, one end usually bearing a knob-like projection; found frequently, but usually not abundant, in clover seed and small grass seed.

Canada thistle seeds (fig. 18, **r**) are smooth, light brown, straight or curved, having a cuplike rim at one end, a projecting point often within the rim; found in clover seed, particularly alsike from Canada; sometimes in seed of clover and grasses from Europe.

Bull thistle seeds (fig. 18, **s**) are larger than those of the Canada thistle, light colored, striped lengthwise with brown, the rim at one end often yellowish; common in red clover, alfalfa, and grass seeds.

Wild chicory seeds (fig. 18, **t**) are brown or straw colored, usually mottled, the crown scales at the broader end sometimes rubbed away; common in imported clover, alfalfa, and certain kinds of grass seeds, occurring in lesser degree in American-grown seed.

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[a] See "An Improved Method of Separating Buckhorn from Red Clover and Alfalfa Seeds," Circular 2, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1908.

Other Weed Seeds Commonly Found in Farm Seeds.

Certain kinds of weed seeds other than those termed noxious under the preceding heading are found frequently, sometimes abundant, in various kinds of farm seeds, and thus cause inquiry from one examining seeds. The degree of noxiousness of this class of weed seeds differs with the kinds and with the conditions of locality, climate, etc., under which they are sown. While some of the kinds included in the present list are looked upon, at least locally, as pests, many of the kinds mentioned are of little importance as field weeds. Since it is essential to distinguish the relatively unimportant from the important seeds, a fairly accurate classification of the weed seeds found in farm seeds with respect to their relative importance is a desirable feature of popular seed testing.

The following brief descriptions refer serially to illustrations of 60 kinds of weed seeds shown in figures 19, 20, and 21.

Crab-grass seeds (fig. 19, **a**) usually bear the outer chaff, which is often soft-hairy, one scale as long as the seed and distinctly 3-ridged, the other half the length of the seed; straw colored, brown, or purplish; common in seeds of clovers, alfalfa, and grasses; plants sometimes very troublesome.

Witch-grass seeds (fig. 19, **b**) occur both with and without the outer chaff, which is lance shaped, smooth, and brown; seeds freed from the chaff are oval, light gray or dark gray, smooth, and polished; common in seeds of clovers, alfalfa, and grasses; plants widely distributed; comparatively unimportant.

Yellow foxtail seeds (fig. 19, **c**) are oval, flat on one side and arched on the other, chaff straw colored, light brown, or greenish, as long as the seed on the flat face, a half-length scale on the arched face; the light-colored or dark-colored seed within the chaff distinctly ridged crosswise on the arched face, often free from the outer chaff; common in many kinds of farm seeds.

Green foxtail seeds (fig. 19, **d**) are oval, convex on both faces, the whitish or straw-colored outer chaff as long as the seed on both faces; seed within the chaff straw colored, gray, or brown, the darker seeds often mottled, the surface finely roughened and dull; common in many kinds of farm seeds. Both yellow and green foxtail grasses are widely distributed summer weeds occupying valuable space in crops. Green foxtail seeds are distinguished from seeds of foxtail millet by their smaller size and rough, dull surface.

Velvet grass seeds (fig. 19, **e**) usually appear in the chaff, which is thin, oval, and straw colored, the surface covered with fine, stiffish hairs; a single oval, shining seed usually found within the chaff; a common impurity of coarse grass seeds.

Soft chess seeds (fig. 19, **f**) are lance shaped, usually much flattened, straw colored, the lemma awned at its apex, its back usually wrinkled, the palea and grain shorter than the lemma; common in imported coarse grass seeds; widely distributed in the United States, but not an important weed except on the Pacific coast.

Sedge seeds (fig. 19, **g**) when covered by the chaffy hull are flask shaped, straw colored, brown, or greenish, flattened and thin with respect to the several kinds found in farm seeds; seeds freed from the outer chaff are oval, lens shaped, and light brown; common in grass seeds, particularly bluegrass seed; plants comparatively unimportant.

Sorrel (or sheep's sorrel) seeds (fig. 19, **h**) are small, oval, 3-angled, the outer chaffy hull dull reddish brown; seeds freed from the hull are reddish brown, smooth, and polished; found in farm seed both with and without the hull; a common impurity, appearing in seeds of clovers, grasses, poorly cleaned cereals, millets, etc.; a cosmopolitan weed often troublesome until subdued.

Knotweed seeds (fig. 19, **i**) are sharply oval, 3-angled, dull reddish-brown in the absence of the brown chaffy covering, a part of which is usually borne at the broader end; common in clover seed and grass seed; plants usually of minor importance as field weeds.

Pale knotweed seeds (fig. 19, **j**) are nearly circular, flattened, and chestnut brown when freed from the reddish-brown, sometimes adherent, chaffy covering; common in seed of coarse grasses, cereals, and flax, often abundant in imported seed. The plants grow chiefly in moist places and are not troublesome on uplands.

Lady's-thumb seeds (fig. 19, **k**) are usually free from the chaffy covering and are then black, shining, broadly oval, and flattened, or sometimes 3-angled; common in

various kinds of farm seeds, particularly American-grown red clover seed. The habit of the plant is similar to that of the preceding knotweeds, to which it is closely related. This plant is common on dry uplands.

Lamb's-quarters (goosefoot) seeds (fig. 19, l) are small, lens shaped, dark brown, or black and shining, sometimes found within a chaffy covering of five scales; common

FIG. 19.—Other weed seeds commonly found in farm seeds (No. 1): **a**, Crab-grass; **b**, witch-grass; **c**, yellow foxtail; **d**, green foxtail; **e**, velvet grass; **f**, soft chess; **g**, sedge; **h**, sorrel; **i**, knotweed; **j**, pale knotweed; **k**, lady's-thumb; **l**, lamb's-quarters; **m**, wild saltbush; **n**, rough amaranth; **o**, spreading amaranth; ; **p**, wild spurry; **q** and **r**, chickweed; **s**, mouse-ear chickweed; **t**, forked catchfly. (Enlarged and natural size.)

in all kinds of farm seeds, particularly clover and grass seeds; a well-known weed of gardens, cultivated fields, and meadows.

Wild saltbush seeds (fig. 19, **m**) are thin, triangular or wedge shaped, veined, straw colored, or purplish, their two scales inclosing a single small seed; found in American-grown alfalfa, not appearing in imported seed.

Amaranth (pigweed) seeds (fig. 19, **n** and **o**) are lens shaped, black, and highly polished. Seeds of rough amaranth (fig. 19, **n**) are oval in outline; those of tumbling

amaranth are somewhat smaller and nearly circular in outline, while seeds of spreading amaranth (fig. 19, o) are much larger and nearly circular in outline, the sides being strongly convex. Seeds of rough amaranth and of tumbling amaranth are common in various kinds of farm seeds, particularly clover. Spreading amaranth is native in the Western States and its seeds often appear in alfalfa from that region.

Wild spurry seeds (fig. 19, p) are very small, black, and nearly spherical. A narrow light-colored rim encircles the seed and serves to distinguish it from other weed seeds. Some seeds are flecked with whitish particles; common in imported clover seed.

Chickweed seeds (fig. 19, q and r) are small, mostly brown, nearly circular, and flattened; one kind (fig. 19, q), common in clover seed imported from Europe, has numerous interlacing wrinkles covering the surface, the other kind (fig. 19, r) is borne by a common weed in lawns, gardens, and thin meadows, has the surface covered with individual tubercles arranged in more or less distinct rows, and is found in both imported and domestic clover seed.

Mouse-ear chickweed seeds (fig. 19, s) are minute, flattened, wedge shaped, tubercled, and distinctly reddish brown; common in small clover and grass seeds, particularly in alsike and timothy produced in Canada. This is a somewhat insignificant weed of lawns and thin meadows.

Forked catchfly seeds (fig. 19, t) are very similar to those of white campion (fig. 17, j), bladder campion (fig. 17, k), and night-flowering catchfly (fig. 17, l), but differ in having the tubercles on each face of the seed arranged in a few distinct rows. These kidney-shaped brown seeds often appear in European-grown red clover and alfalfa seed.

Creeping buttercup seeds (fig. 20, a) are oval, flattened, brown or reddish brown, with a lighter rim, and have a prominent, straight, or slightly curved beak; common in imported crimson clover, meadow fescue, and rye-grass seeds.

Peppergrass seeds (fig. 20, b) are oval, flattened, thin, reddish yellow, and have a curved groove on each face; common, and sometimes abundant, in clover and grass seeds, particularly in timothy; a widely distributed annual weed of waysides, gardens, and meadows.

Shepherd's-purse seeds (fig. 20, c) are minute, reddish yellow, oblong, and flattened, with two more or less distinct grooves on each face; common in seeds of white, alsike, and poorly cleaned red clovers; a cosmopolitan, annual weed.

Cinquefoil seeds (fig. 20, d) are minute, straw colored, oval, and lens shaped, the faces bearing curved and forked ridges; common in alsike clover and timothy.

Hop clover seeds (fig. 20, e) are minute, elliptical, yellowish, the surface smooth and shining; common in poorly cleaned clover seed. The reddish flowers (shown at the right of the figure) are common in imported orchard grass, meadow fescue, and rye-grass seeds.

Yellow trefoil seeds (fig. 20, f) are oval with a projecting point on the edge, yellowish brown, or tinged with green. Besides being used as an adulterant of clover and alfalfa seed, some seeds occur incidentally in clover and grass seeds. Mature, black, oval pods or immature green pods are common in coarse grass seeds. The plants are widely distributed here and in foreign countries.

Bird's-foot trefoil seeds (fig. 20, g) are small, nearly spherical, brown, and often mottled; frequently found in imported clover and alfalfa seeds; a cultivated plant in Europe.

Wild geranium seeds (fig. 20, h, i, and j) as commonly found in farm seeds represent three kinds of plants. Seeds of one kind (fig. 20, h) are oblong and pitted, having a whitish or light-brown network over a darker brown background (thus readily distinguished from other seeds); common in imported crimson clover and coarse grass seeds. Another kind (fig. 20, i) has smaller, smooth, rounded seeds which are often covered by a brown hull bearing several diagonal ridges on each side; often found in imported clover and grass seeds. A third kind (fig. 20, j) has more oval, smooth seeds, some of which are covered by a somewhat flattened, finely hairy hull; found in imported clover and grass seeds.

Stork's-bill seeds (fig. 20, k) are somewhat club shaped, smooth, brown, and often covered by a sharp-pointed, brown, hairy hull; found in clover, alfalfa, and grass seeds; commonest in imported seed.

Spurge seeds (fig. 20, l) are steel gray or dark brown, oval, and somewhat 4-angled, the angles lightest colored, a few cross-ridges between the angles, one of the angles bearing a slender, black line; common in American red clover seed.

Spiny sida seeds (fig. 20, m) are brown, rounded on one side, angular on the other, and notched at the broader end; common in American-grown red clover seed; the forked, often netted-veined seed vessels (shown at right-hand side of figure) sometimes appear in poorly cleaned clover, but are more common in grass seeds.

Evening primrose seeds (fig. 20, **n**) are small, reddish brown, and angular, prismatic, or curved; the corners are thin-edged, the faces finely grooved; common in timothy and sometimes found in clover seed.

Red pimpernel seeds (fig. 20, **o**) are small, 3-angled, and reddish brown; surface finely roughened or sometimes partly smooth and black; somewhat resemble seeds of sorrel (fig. 19, **h**) having the chaffy covering; very common in imported clover and alfalfa seeds, often in grass seed.

Sticktight seeds (fig. 20, **p**) are small, oval, brown burs having many barbed prickles;

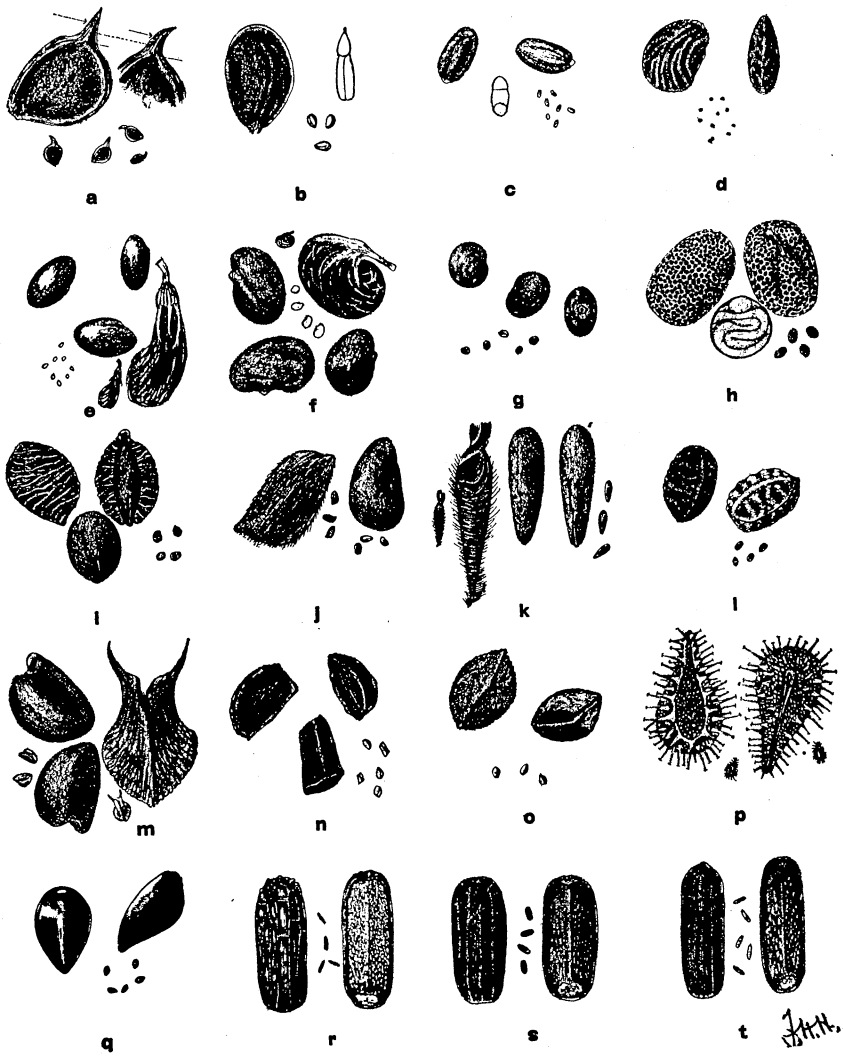

FIG. 20.—Other weed seeds commonly found in farm seeds (No. 2): **a**, Creeping buttercup; **b**, pepper-grass; **c**, shepherd's-purse; **d**, cinquefoil; **e**, hop clover; **f**, yellow trefoil; **g**, bird's-foot trefoil; **h**, **i**, and **j**, wild geraniums; **k**, stork's-bill; **l**, spurge; **m**, spiny sida; **n**, evening primrose; **o**, red pimpernel; **p**, sticktight; **q**, forget-me-not; **r**, **s**, and **t**, vervain. (Enlarged and natural size.)

when in clover, most of the prickles are usually broken away; when in grass seeds, some or all of the prickles are usually uninjured; found in red clover, particularly that from Canada, in seed of coarse grasses, millets, cereals, and flax; often in seed imported from Europe.

Forget-me-not seeds (fig. 20, **q**) are small, black, shining, oval, rounded on one face, and angled on the other; common in imported clover and grass seeds.

Vervain seeds (fig. 20, **r**, **s**, and **t**) are oblong, reddish or dark brown, veined on one side, angled and often gray on the other. One kind (fig. 20, **r**) has a distinct network of ridged veins on the back, the surface between the veins shining; common in European clover and alfalfa seeds. The other two kinds of vervain commonly found in farm seeds have indistinct veins on the back which is dull, one of them

FIG. 21.—Other weed seeds commonly found in farm seeds (No. 3): **a**, Catmint; **b**, healall; **c**, rough-leaved toadflax; **d**, smaller broad-leaved plantain; **e**, bracted plantain; **f**, dwarf plantain; **g**, field madder; **h**, cleavers; **i** and **j**, wild corn salad; **k**, poverty weed; **l**, black-eyed Susan; **m**, dog fennel; **n**, field camomile; **o**, scentless camomile; **p**, corn flower; **q**, cat's-ear; **r**, oxtongue; **s**, hawkweed picris; **t**, hawkweed. (Enlarged and natural size.)

(fig. 20, **s**) being comparatively broad and brown; the other (fig. 20, **t**) being slender and lighter, reddish colored; seeds common in American-grown clover seed.

Catmint seeds (fig. 21, **a**) are oval, dark reddish brown or darker, smooth and dull, readily distinguished by the two white scar spots, side by side at one end of the seed; common in clover seed, particularly Canadian-grown alsike.

Healall seeds (fig. 21, **b**) are light brown, oval, with a characteristic whitish appendage at the pointed end, faint dark lines traversing the faces and edges; one of the commonest impurities of both domestic and imported clover and grass seeds.

Rough-leaved toadflax seeds (fig. 21, **c**) are very small, oblong, having a light-brown, wrinkled surface; plants not evidently important, but the seeds, as common impurities of imported clover seed, indicate the foreign origin of the lots containing them.

The smaller broad-leaved plantain seeds (fig. 21, **d**) are similar to those of rat-tail plantain (fig. 18, l), but are smaller, greenish or brown, the surface having slender, wavy dark lines; common in poorly cleaned clover and grass seed.

Bracted plantain seeds (fig. 21, **e**) are similar to those of buckhorn (fig. 18, **m**), but they are broader, dull reddish brown, and the broad groove on one face is bordered by a white stripe; the rounded face is crossed near its center by a shallow groove; common in American-grown red clover seed; sometimes found in alfalfa and grass seeds and occasionally in imported seed; a common annual plant of light lands.

Dwarf plantain seeds (fig. 21, **f**) are light brown, oval, rounded on one face, and broadly grooved on the other; found in crimson clover seed produced in Atlantic Coast States.

Field madder seeds (fig. 21, **g**) are oval, gray in having numerous white surface spots, some of the seeds having three frail, whitish teeth, others devoid of the teeth; common in seed of clover, alfalfa, and grasses; confined chiefly to imported seed.

Cleavers seeds (fig. 21, **h**) are coarse, circular, one face rounded, the other depressed in the center; the surface is covered with hair-bearing tubercles from which the hairs may be more or less rubbed away; the entire outer surface is sometimes rubbed away, leaving the seed smooth and brown; common in seed of coarse grasses, millets, cereals, and flax; a common impurity of imported seed.

Seeds of wild corn salad representing two kinds, commonly appear in clover imported from Europe. They are brown, one kind (fig. 21, **i**) being slenderly oval and nearly smooth, the other (fig. 21, **j**) being broader and usually more or less covered with white hairs. The presence of these seeds in clover indicates its foreign production.

Poverty weed seeds (fig. 21, **k**) are oval and dull brown, straight, or somewhat curved. They occur in alfalfa seed from the Western States; not found in foreign-grown seed.

Black-eyed Susan, or yellow daisy, seeds (fig. 21, l) are minute, black, prismatic, finely ridged lengthwise, and 4-angled; found chiefly in timothy seed.

Mayweed (dog fennel) seeds (fig. 21, **m**) are oval or club shaped, straw colored or brown, ridged lengthwise, the ridges more or less distinctly tubercled; very common in both domestic and imported seed of clover and grasses.

Field camomile seeds (fig. 21, **n**) are prismatic, some broad and deeply grooved lengthwise, others slender and lightly grooved or smooth; color whitish, light brown, or dark brown; common in domestic and imported clover and grass seeds.

Scentless camomile seeds (fig. 21, **o**) are prismatic, the surface rough and black, one face having three prominent brown ribs, the other showing two of these ribs and a partial third rib; common in poorly-cleaned clover seed and grass seed, particularly the seed of sweet vernal grass imported from Europe.

Corn flower (blue bottle) seeds (fig. 21, **p**) are easily recognized by the bluish color of the body of the seed and the tawny color of the brush of bristles each bears; common in both domestic and imported coarse seeds, including crimson clover, grasses, cereals, millets, and flax.

Cat's-ear seeds (fig. 21, **q**) are slender, reddish brown, rough, and sometimes bear a slender beak tipped by a brush of whitish bristles; found in clover seed and grass seed, a common impurity of imported seed.

Oxtongue seeds (fig. 21, **r**) are mostly lance shaped, reddish yellow, the surface having dark transverse lines, the margin at the broader end of the seed roughened (as shown at the left of the figure); a part of the seeds whitish, curved, the inner curved edge white-hairy (shown at the upper right-hand of the figure); common in poorly cleaned red clover and alfalfa seed imported from Europe; not found in domestic-grown seed.

Hawkweed picris seeds (fig. 21, **s**) are reddish brown, straight or curved, bearing fine transverse, dark-edged ridges, the faces of the seed having one or two slender grooves lengthwise; frequently found in imported red clover and alfalfa seed.

Hawkweed seeds (fig. 21, **t**) are small, black, cylindrical, ridged lengthwise, pointed at one end, the opposite end bearing a short brush of fine, white bristles; common in grass seed. The seeds of several kinds of hawkweed are similar. One kind is the orange hawkweed, which has proved troublesome in the Northeastern States.

DETAILS OF MAKING SEED TESTS.

Procedure.—Certain details of procedure in making seed tests should be followed if tests of seeds of different kinds are to be fairly comparable. The natural course to be followed in testing forage-crop seeds involves, in general, the preparation of the small sample for actual test, its examination, the separation of the crop seed and its impurities, a test of the germinating power of the crop seed, and the determination of the actual value of the seed as compared with pure seed.

Careful work in making a test is comparatively useless if the sample does not fairly represent the bulk of the seed from which it is taken.

The responsibility for selecting the small trade sample rests entirely with the dealer who submits it. When seed in bulk, as in a sack, is to be sampled, small amounts of seed should be taken from the top, bottom, sides, and center of the sack. If the sack be emptied and the seed thoroughly mixed, it is probable that a fairer sample can be taken.

The test sample.—Since the small sample thus taken or the trade sample will be too large to be tested in its entirety, it must be again subdivided to obtain the test sample. In official tests this all-important subdivision is effected by the use of a mechanical mixer, which takes a little from all parts of the larger quantity. In home testing perhaps there is no better plan than to pour the seed in a symmetrical pile on a flat surface and carefully subdivide it by means of a table knife. A subdivision amounting to a teaspoonful for the clovers and small-seeded grasses, a tablespoonful for the coarse grass seeds, and a considerably larger amount for cereal grains may be accepted for the test.

The balance previously described (p. 11) having been put in proper condition for use, the total weight of the selected sample is to be taken and recorded in terms of whole and fractional shots. This permits the computation of percentages by ordinary division according to the methods used in percentage. If, however, quantities of seed balancing 6¼ or 12½ shots are used, the one-sixteenth shot weight represents 1 per cent or one-half of 1 per cent, as heretofore explained.

The pure seed.—After the sample is weighed it is spread on a sheet of white paper folded in the form of a tray (p. 14) and should first be examined with reference to whether it is true to name. Attention should then be directed to the possible presence of some particular adulterant liable to be present. All the foreign seeds (except certain adulterants), including other crop seeds and weed seeds, also inert matter, as pieces of stems, chaff, sand, and badly broken seeds, are to be separated from the kind under test. Both plump and shriveled crop seed should be classed as "pure seed." While the shriveled seed very evidently may be worthless, it nevertheless is a part of the crop seed, and its worthlessness will appear in the subsequent germination test.

If certain specific adulterants, as trefoil, sweet clover, bur clover, Canada bluegrass, and rye-grass, are found, the adulterant seeds are left mixed with the crop seed when the other foreign seeds are separated. The proportion of the adulterant is then determined by count from a part of the mixture.

If certain kinds of foreign crop seeds or of weed seeds are especially abundant it may be desirable to keep them separate from the rest in order to determine their quantity, but if not the foreign matter for convenience may be mixed together irrespective of its character. In official tests the foreign seed and the inert matter are separated, their quantities being determined individually. After the pure seed and the foreign materials of the sample have been separated the proportion of pure seed is determined by comparing its weight with that of the entire sample, expressing the result in per cent. If quantities of seed weighing $6\frac{1}{4}$ shots or $12\frac{1}{2}$ shots have been taken for the original test sample, each $\frac{1}{16}$-shot weight of pure seed represents 1 per cent or one-half of 1 per cent, respectively.

Determination of adulterants.[a]—When an adulterant is found and its kind ascertained by examination, its quantity must be determined. When such seed as that of trefoil, sweet clover, Canada bluegrass, and other kinds have been used, their separation from all the pure seed of a test sample is laborious and not justified by the information gained. Since the weight of these seeds is approximately the same as that of the seeds with which they are mixed, their relative proportion to pure seed is determined by count. After all other foreign seeds and other materials have been separated from the pure seed and adulterant together 1,000 seeds of the mixed crop seed and adulterant are counted out indiscriminately. This number of seeds is then carefully separated into pure-crop seed and adulterant and the number of each ascertained by actual count. If a sample of red clover seed is found to be adulterated with trefoil to the extent of 400 seeds in 1,000 seeds of the mixture, the trefoil is determined to be $400 \div 1{,}000 = 40$ per cent of the mixture. If other foreign matter in the sample amounts to 15 per cent, the clover and trefoil mixture represents 85 per cent of the original sample. The trefoil adulterant therefore amounts to 40 per cent of 85 per cent, or 34 per cent of the seed under test.

Examination of weed seeds.—The weed seeds should be examined for kinds representing important weeds. A knowledge of what important weed seeds are liable to occur in particular kinds of crop seed is very helpful. For this reason the results of many tests are utilized in the subsequent remarks on testing particular kinds of seed. Suspected weed seeds should be carefully compared with the illustrations relating to this class of seeds. Many kinds of weed seeds not illustrated in this bulletin will be found. Most of these, as a rule, are of relatively minor importance.

The germination test.—It is important in separating pure seed for the germination test that the counting be done indiscriminately—without selection as to the appearance of the seed. The tendency of the beginner is to select the more promising-looking seeds for the germination test. It must not be forgotten that the purpose of the test is to learn what percentage of the total pure seed will germinate. If the more promising seed is selected, the results of the test are deceiving in favor of the dealer.

Of small seeds (such as forage crop and cereals), 200 are counted; of larger seeds 100 are taken, each in duplicate. In the special indi-

[a] See Farmers' Bulletin 382, entitled "The Adulteration of Forage-Plant Seeds."

vidual ear tests of corn only a few seeds are used. In adulterated samples the necessary number of pure seeds can usually be obtained from the separation of the 1,000 seeds. It is obvious that accurate counting is important to insure accuracy in computing the result.

The conditions essential to seed germination are sufficient moisture, warmth, and air. Sufficient water should be supplied to keep the seeds thoroughly moistened during germination, but they should not be allowed to rest in water. The temperature of living rooms ranging from 65° to 85° F. is suitable for germination. A place in the room should be selected where the day and the night temperatures will be fairly uniform. Thus the window sill is too cold in winter and a shelf directly over the stove is too warm. The germination of some kinds of seeds is favored by the varying day and night temperature of living rooms. Germinating seeds must be supplied with fresh air. If the air is confined, it loses its oxygen, which is necessary to germination, and there is no means for escape of carbon dioxid, a gas produced by the germination process but detrimental to it. A proper covering of cloth, paper, wood, or glass for the seed germinator which prevents too rapid loss of moisture by evaporation, while not hindering the admission of air, should not be neglected. In order to insure sufficient air, very small seeds germinate best on top of the germinator cloth or paper, while larger seeds do better when placed between cloth or paper folds.

When sand or soil is used in testing germination, the seeds should have but a very light covering. Before the sprouts appear the surface of the sand may be kept covered to hold the moisture. Germination in sand and in soil is likely to be somewhat slower than when the test is made in cloth or paper.

Seed in the germinator should be examined daily to note the extent and vigor of germination. Weak, slow germination indicates low vitality, unpromising for good field results in plant production.

Red clover and alfalfa seed are sometimes so slow in absorbing moisture that the germination is delayed several days or even several weeks. This is particularly true of new seed. The same seed a year later may show a greatly reduced amount of this so-called "hard seed" and therefore a higher percentage of germination under test. Such seed remains hard in the test when other seed has become soft by the absorption of water.

The time required for germination differs with different kinds of seed. Between the times of appearance of the first and the last sprouts there is a period of maximum germination when the practical germinating value of the seed is evident.

Determining the actual value of the seed.—The actual value of the pure, germinable seed in a sample depends on its quantity, as compared with the total weight of the sample. Assuming, for illustration, a standard of absolute purity and viability in seed selling at $10 per 100 pounds, such seed is actually worth, at this rate, 10 cents per pound. On the other hand, seed selling at the same price, but on test showing a purity of 80 per cent and viability of 70 per cent, contains but 70 per cent of 80 per cent, or 56 per cent of pure, viable seed. At $10 per 100 pounds of this seed as sold the good seed actually costs nearly 18 cents per pound.

This ideal state of perfection in purity and viability of seed is rarely, if ever, attained. It is important, however, to know the highest quality that seed can justly be expected to show. It is fair that the best seed that is marketed should serve as a guide in this respect, because the average results of miscellaneous tests of any particular kind are too low, since some samples are altogether too low in quality. The fact that seed of the principal forage crops in which both the purity and the viability closely approach 100 per cent does appear on the market justifies one in assuming that all seed of these crops sold as high grade should possess equally good quality.

The practical application of this understanding as to quality may sometimes admit of due allowance. For example, clover seed is sometimes sold locally in the chaff. If such seed is known to be free from noxious weed seeds, it can safely be purchased if proper allowance be made for the proportion of worthless chaff and undeveloped seed. An average sample of the chaffy seed may be weighed and its percentage of good seed ascertained. Since clover seed weighs 60 pounds per bushel, the actual value of such chaffy seed can readily be determined, the price regulated, and the quantity to be sown accurately gauged.

The actual proportion of pure, viable seed in a sample is represented by the product of its percentages of purity and viability expressed in per cent.

TESTING PARTICULAR KINDS OF SEEDS.

GENERAL CONSIDERATIONS.

The work of seed testing is greatly facilitated by a general knowledge of the conditions more or less peculiar to the seed of particular kinds of crops. For illustration, the adulterants used with different kinds of seeds differ in kind; the conditions of culture, of harvesting, and of preparation for market tend to influence the condition of the seed; the kind and source of the seed influence the character of its impurities. Kinds of seed supplied to the market from both domestic and foreign grown stocks should be considered with reference to their source. The significance of the kinds of weed seeds as indicating the source of the seed is at present chiefly applicable to the seed of the clovers and alfalfa.

In the following remarks on the testing of particular kinds of seeds it is assumed that the previously discussed methods of making seed tests in general will be borne in mind, leaving the present discussion to relate chiefly to conditions peculiar to the several kinds of seeds considered. To avoid repetition, it may be stated that for the test sample of clovers, alfalfa, and medium-seeded grasses seed equaling 12½ BB shots in weight may be taken; of the smaller seeded redtop and bluegrasses half this weight, equal to 6¼ BB shots, will suffice; of coarse seeds (as oats, barley, vetch, etc.), double the weight of 12½ BB shots may be used. Several subdivisions of the larger sample may thus be required to segregate the small test sample. A little care will insure accuracy in weighing the test sample.

TESTING RED CLOVER SEED.[a]

The yellow and violet colors of the seed, together with the triangular form of individual seeds, distinguish fresh red clover seed. (See fig. 22.) Old seeds are dull and reddish brown. Imperfectly developed seeds are dull brown and more or less shriveled. Empty perforated seed shells in light screenings show the work of the clover seed chalcis fly.[b] No evidence of the so-called clover seed midge is ever present in seed. Note should be made of the apparent relative quantity of poor true clover seed in the sample.

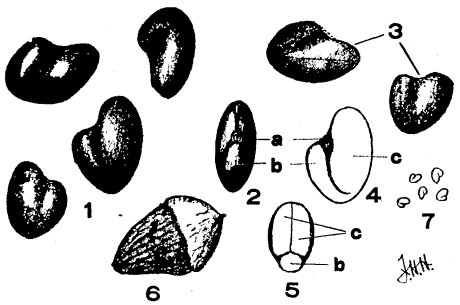

FIG. 22.—Seeds of red clover: 1, Side view and, 2, edge view of seeds; 3, the triangular form indicated; 4, a seed cut lengthwise; 5, a seed cut crosswise, showing the embryo; a, seed scar; b, stemlet (radicle) of the embryo; c, seed leaves (cotyledons) of the embryo; 6, a pod of red clover; 7, natural size of seeds.

Consider the matter of intentional adulteration by the use of (1) old red clover seed which is sometimes disguised by oiling and polishing, but which will be disclosed in the germination test; (2) yellow trefoil seed (figs. 3 and 23); and (3) miscellaneous screenings consisting of shriveled clover seed and weed seeds, or of very small red clover seed indicating foreign production.

Separate all true red clover seed, together with yellow trefoil present in quantity sufficient to indicate intentional adulteration, from all weed seeds and other materials.

If the sample is adulterated with trefoil or other specific adulterant, count out 1,000 seeds from the clover and adulterant freed from other impurities and determine the quantity of the adulterant by count (p. 30).

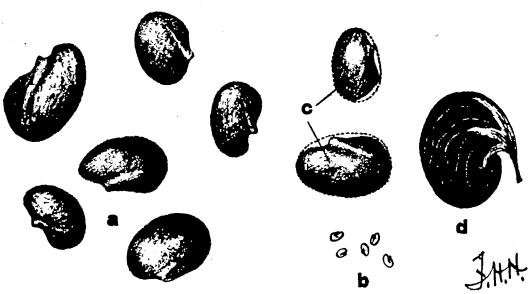

FIG. 23.—Seeds of yellow trefoil: a, Seeds showing variation in form and size; b, natural size of seeds; c, oval form of trefoil seeds indicated; d, a pod of trefoil.

The total quantity of true red clover seed, including shriveled seed, is the "pure seed" of the test; accurately record its weight. The percentage of true red clover seed in the test sample and in the original sample is shown by dividing this weight by the weight of the original sample, expressing the result in per cent; or, if seed equal to the weight of 12½ BB shot is being tested, each $\frac{1}{16}$-shot weight represents one-half of 1 per cent of the whole.

[a] See Farmers' Bulletin 260, entitled "Seed of Red Clover and Its Impurities."

[b] See "Some Insects Affecting the Production of Red Clover Seed," Circular 69, Bureau of Entomology, U. S. Dept. of Agriculture, 1906.

Count indiscriminately from the pure seed 200 seeds in duplicate for the germination test. Conduct this test as previously directed under "The germination test" (p. 30). Sprouting should begin the second day and be completed by the sixth day. At the completion of the sprouting, examine seeds which have not sprouted to determine whether they are hard or soft. In general, the presence of a considerable quantity of hard seed indicates that the sample is one of new seed. The hard seed may amount to 20, 30, or even 50 per cent in red clover seed 1 year old. Although such hard seed is probably all alive, it is practically worthless for seeding. Soft seeds which do not sprout may be considered as dead before the test was made. An excess of such seed indicates the use of old seed as an adulterant.

The best red clover seed tests as high as 98 or 99 per cent purity and 99 per cent viability.

The foreign seeds in red clover may include other crop seeds, as alsike clover, white clover, or timothy. Note should be made of the presence, character, and quantity of such crop seed.

The weed seeds should be considered with respect to their total quantity and their character as affecting the clover crop and the land. Seeds of strictly noxious plants should be distinguished as well as those indicating the domestic or foreign source of the seed. Rural school pupils, especially, who make tests of seeds should be interested in identifying, so far as possible, the kinds of all the weed seeds found.

The noxious weed seeds found in red clover seed include: (Fig. 17) dock (f), black bindweed (g), Russian thistle (h), white campion (j), bladder campion (k), night-flowering catchfly (l), pennycress (n), field peppergrass (o), two kinds of false flax (p and q), black mustard (s), English charlock (t); (fig. 18) Indian mustard (a), wild carrot (d), field bindweed (e), clover dodder (g), field dodder (i), corn gromwell (k), rat-tail plantain (l), buckhorn (m), ragweed (n), wild sunflower (p), oxeye daisy (q), Canada thistle (r), bull thistle (s), wild chicory (t).

Other weed seeds commonly found in red clover seed include: (Fig. 19) crab-grass (a), witch-grass (b), yellow foxtail (c), green foxtail (d), velvet grass (e), sedge (g), sorrel (h), knotweed (i), pale knotweed (j), lady's-thumb (k), lamb's-quarters (l), rough amaranth (n), spreading amaranth (o), wild spurry (p), two kinds of chickweed (q and r), mouse-ear chickweed (s), forked catchfly (t); (fig. 20) creeping buttercup (a), peppergrass (b), shepherd's purse (c), cinquefoil (d), hop clover (e), yellow trefoil (f), bird's-foot trefoil (g), wild geraniums (h, i, and j), stork's-bill (k), spurge (l), spiny sida (m), evening primrose (n), red pimpernel (o), sticktight (p), forget-me-not (q), three kinds of vervain (r, s, and t); (fig. 21) catmint (a), healall (b), rough-leaved toadflax (c), smaller broad-leaved plantain (d), bracted plantain (e), field madder (g), cleavers (h), wild corn salad (i), black-eyed Susan (l), dog fennel (m), field camomile (n), scentless camomile (o), cat's-ear (q), oxtongue (r), hawkweed picris (s).

The American or the Canadian origin of red clover seed is strongly indicated by the presence of the following weed seeds: (Fig. 17) night-flowering catchfly (l); (fig. 18) field dodder (i), rat-tail plantain (l), ragweed (n), bull thistle (s); (fig. 19) witch-grass (b), lady's-thumb (k), spreading amaranth (o); (fig. 20) peppergrass (b), cinquefoil (d), spurge (l), spiny sida (m); (fig. 21) bracted plantain (e). Seeds of Canada thistle (fig. 18, r) or of small-fruited false flax (fig. 17, q), if found in abundance, indicate that the source of the seed is Canadian.

European origin of red clover seed is indicated by the presence of certain weed seeds, and the occurrence of several kinds of these in the same sample (especially in the absence of the kinds heretofore mentioned as occurring in American-grown seed), lends weight to the probability of European origin, as follows: (Fig. 18) clover dodder (g), wild chicory (t); (fig. 19) wild spurry (p), chickweed (q), forked catchfly (t); (fig. 20) bird's-foot trefoil (g), wild geraniums (h, i, and j), red pimpernel (o), forget-me-not (q), vervain (r); (fig. 21) field madder (g), wild corn salad (i and j), scentless camomile (o), oxtongue (r), hawkweed picris (s). The presence of a considerable quantity of distinctly small-seeded red clover seed further indicates European origin.

TESTING ALSIKE CLOVER SEED.

Alsike clover seed is distinguished from other kinds by its dark-green color, the small size, and the heart-shaped oval form of individual seeds. The lighter colored seeds are often mottled (fig. 24). Old seed is distinguished from new by the dull, reddish-brown color it acquires.

White clover seed often appearing in alsike seed is distinguished by its yellowish or pinkish color.

Yellow trefoil seed, sometimes used as an adulterant and often present as an incidental impurity, is coarser than the alsike seed and is further distinguishable by its greenish-yellow or brown color and the characteristic form of individual seeds (compare figs. 23 and 24). Adulterants used other than trefoil seed are old alsike seed, timothy seed, and weedy screenings (fig. 8).

Germination proceeds between the second and sixth days of the test, and the viability often attains 99 per cent. Hard seed is less frequently observed in alsike seed than in red clover. The purity commonly amounts to 98 or 99 per cent.

The noxious weed seeds occurring in alsike clover seed include: (Fig. 17) dock (**f**), white campion (**j**), bladder campion (**k**), night-flowering catchfly (**l**), pennycress (**n**), field peppergrass (**o**), small-fruited false flax (**q**), English charlock (**t**); (fig. 18) tumbling mustard (**c**), clover dodder (**g**) very rarely rat-tail plantain (**l**), buckhorn (**m**), ragweed (**n**), oxeye daisy (**q**), and frequently Canada thistle (**r**).

Other common weed seeds in alsike seed include: (Fig. 19) witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), velvet grass (**e**), sedge (**g**), sorrel (**h**), knotweed (**i**), lamb's-quarters (**l**), rough amaranth (**n**), spreading amaranth (**o**), wild spurry (**p**), chickweeds (**q** and **r**), mouse-ear chickweed (**s**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**), hop clover (**e**), yellow trefoil (**f**), spurge (**l**), evening primrose (**n**), forget-me-not (**q**), vervain (**t**); (fig. 21) catmint (**a**), healall (**b**), smaller broad-leaved plantain (**d**), bracted plantain (**e**), dog fennel (**m**), field camomile (**n**), scentless camomile (**o**).

FIG. 24.—Seeds of alsike clover: **a**, Seeds showing variation in form and surface appearance, enlarged; **b**, natural size of seeds.

So little alsike clover seed is imported from Europe that weed seeds indicating European origin of seed are uncommon in this kind of seed. The examination of various samples of European seed shows, however, that the weed seeds found in European red clover seed, previously stated, are essentially the same as those appearing in alsike seed from the same source. Clover dodder (fig. 18, **g**) is particularly noticeable in most of the samples of European alsike clover seed.

TESTING WHITE CLOVER SEED.

White clover seed resembles that of alsike clover in size and form of individual seeds, but the average size is slightly smaller. The light-yellow, pinkish, or light-brown color of white clover seed distinguishes it from the darker alsike. Adulteration is confined chiefly to the use of old seed and of weedy screenings. Much seed imported from Europe is on the American market.

The purity should attain 98 or 99 per cent, the viability 99 per cent; sprouting proceeds from the second to the sixth day.

The noxious weed seeds appearing in white clover seed include: (Fig. 17) dock (f), night-flowering catchfly (l), pennycress (n), false flax (p and q), English charlock (t); (fig. 18) tumbling mustard (c), wild carrot (d), clover dodder (g), rat-tail plantain (l), buckhorn (m), oxeye daisy (q), Canada thistle (r).

Other weed seeds commonly appearing in white clover seed are: (Fig. 19) witch-grass (b), green foxtail (d), velvet grass (e), sorrel (h), knotweed (i), lady's-thumb (k), rough amaranth (n), wild spurry (p), chickweeds (q and r), mouse-ear chickweed (s), forked catchfly (t); (fig. 20) peppergrass (b), shepherd's purse (c), cinquefoil (d), hop clover (e), yellow trefoil (f), wild geraniums (i, j), red pimpernel (o), forget-me-not (q), vervain (t); (fig. 21) catmint (a), healall (b), smaller broad-leaved plantain (d), field madder (g), wild corn salad (i), dog fennel (m), field camomile (n), scentless camomile (o), hawkweed picris (s).

White clover seed imported from Europe is often infested with most of the kinds of weed seeds enumerated. American-grown seed may carry seeds of (fig. 17) dock (f), night-flowering catchfly (l), false flax (q), English charlock (t); (fig. 18) wild carrot (d), rat-tail plantain (l), buckhorn (m), oxeye daisy (q); (fig. 19) witch-grass (b), green foxtail (d), sorrel (h), lamb's-quarters (l), etc. The absence of seeds usually found only in seed imported from Europe is most suggestive of the domestic origin of white clover seed.

The weed seeds fairly characteristic of European-grown white clover seed, especially when taken collectively, include: (Fig. 18) clover dodder (g); (fig. 19) wild spurry (p), chickweed (q), forked catchfly (t); (fig. 20) wild geranium (i and j), red pimpernel (o), forget-me-not (q); (fig. 21) field madder (g), wild corn salad (i), scentless camomile (o), hawkweed picris (s).

FIG. 25.—Seeds of crimson clover (enlarged and natural size).

TESTING CRIMSON CLOVER SEED.

The seed of crimson clover is larger than that of the other clovers, the individual seeds being elliptical and so slightly flattened that they roll readily on a flat surface (fig. 25). Fresh seed is pinkish and has a bright luster. As the seed ages it becomes dull and reddish brown. The viability deteriorates rapidly. Adulteration is confined chiefly to the use of old seed, which may usually be distinguished by its color. Considerable trefoil and red clover screenings sometimes appear. Dodder occurs only in lots containing dodder-infested red clover screenings, because the crimson clover is harvested before dodder seed matures.

Most of the crimson clover seed in the American market is imported from Europe. American seed is produced chiefly in Delaware, New Jersey, and Maryland. A white-seeded variety of crimson clover is imported from Europe.

The purity of this seed should be 99 per cent or higher. The viability should be 98 or 99 per cent. Very little hard seed appears in the germination test, which ranges from two to six days in duration.

The noxious weed seeds found in crimson clover seed include: (Fig. 17) chess (c), darnel (d), dock (f), black bindweed (g), corn cockle (i), white campion (j), bladder campion (k), night-flowering catchfly (l), pennycress (n), field peppergrass (o), false flax (p and q), ball mustard (r), black mustard (s), English charlock (t); (fig. 18) Indian mustard (a), hare's-ear mustard (b), wild carrot (d), clover dodder (g), field dodder (i), corn gromwell (k), rat-tail plantain (l), buckhorn (m), oxeye daisy (q), Canada thistle (r), wild chicory (t).

Other weed seeds commonly found in crimson clover seed include: (Fig. 19) crab-grass (a), witch-grass (b), yellow foxtail (c), green foxtail (d), soft chess (f), sorrel (h), knotweed (i), pale knotweed (j), lamb's-quarters (l), wild spurry (p), chickweeds (q and r), forked catchfly (t); (fig. 20) creeping buttercup (a), peppergrass (b), shepherd's purse (c), hop clover (e), yellow trefoil (f), bird's-foot trefoil (g), three kinds of wild

geranium (h, i, and j), stork's-bill (k), spurge (l), red pimpernel (o), forget-me-not (q), vervain (r); (fig. 21) healall (b), rough-leaved toadflax (c), smaller broad-leaved plantain (d), dwarf plantain (f), field madder (g), cleavers (h), wild corn salad (i and j), dog fennel (m), field camomile (n), scentless camomile (o), corn flower (p), cat's-ear (q), hawkweed picris (s).

Crimson clover seed of domestic production is often characterized by the presence of one or more of several kinds of weed seeds, some of which are not considered in this bulletin. Two of these kinds, however, are spurge (fig. 20, l) and dwarf plantain (fig. 21, f). The absence of the kinds given in the following list affords strong indication of domestic production.

The weed seeds especially suggestive of European production include: (Fig. 19) chickweed (q), forked catchfly (t); (fig. 20) creeping buttercup (a), bird's-foot trefoil (g), wild geraniums (h, i, and j), red pimpernel (o), forget-me-not (q), vervain (r); (fig. 21) rough-leaved toadflax (c), field madder (g), wild corn salad (i and j), scentless camomile (o), hawkweed picris (s). The presence of white seeds of crimson clover is an additional indication of European production.

TESTING ALFALFA SEED.

Alfalfa seed is distinguishable from the clover seeds by the somewhat variable kidney-shaped form of individual seeds (figs. 2, 4, 5, 6, and 26) and by the greenish-yellow or light-brown color. Old, poorly developed, and shriveled seeds have a dull, reddish-brown color. In general the details of testing red clover seed (p. 33) may be followed in testing alfalfa.

FIG. 26.—Seeds of alfalfa: a, Individual seeds, showing variation in form; b, edge view of a seed, showing the scar; c, natural size of seeds.

Alfalfa seed is adulterated by the use of (1) yellow trefoil (figs. 4 and 23), (2) sweet clover (figs. 5 and 27), (3) bur clover (fig. 6), (4) light, shriveled alfalfa screenings or low-grade, weedy seed.

Besides giving especial attention to the matter of adulteration the question of domestic or of European production should be considered in making the purity test. Much of the seed on the market is imported and the question of domestic or foreign production often can be determined by the weed seeds present.

The purity should attain 98 or 99 per cent, the viability 97 to 99 per cent. The germination test should be completed in six days, most of the seeds sprouting during the second and third days. Considerable hard seed is often found in new seed.

The noxious weed seeds found in alfalfa seed include: (Fig. 17) sand bur (a), wild oat (b), chess (c), quack-grass (e), dock (f), black bindweed (g), Russian thistle (h), corn cockle (i), white campion (j), bladder campion (k), night-flowering catchfly (l), cow cockle (m), pennycress (n), field peppergrass (o), false flax (p and q), black mustard (s), English charlock (t); (fig. 18) Indian mustard (a), hare's-ear mustard (b), tumbling mustard (c), wild carrot (d), field bindweed (e), clover dodder (g), small-seeded alfalfa dodder (h), field dodder (i), large-seeded alfalfa dodder (j), corn gromwell (k), rat-tail plantain (l), buckhorn (m), ragweed (n), gumweed (o), wild sunflower (p), oxeye daisy (q), Canada thistle (r), bull thistle (s), wild chicory (t).

Other weed seeds commonly found in alfalfa seed include: (Fig. 19) crab-grass (a), witch-grass (b), yellow foxtail (c), green foxtail (d), soft chess (f), sorrel (h), knotweed (i), pale knotweed (j), lady's-thumb (k), lamb's-quarters (l), wild saltbush (m), rough amaranth (n), spreading amaranth (o), wild spurry (p), chickweeds (q and r), mouse-ear chickweed (s), forked catchfly (t); (fig. 20) creeping buttercup (a), peppergrass (b), shepherd's purse (c), cinquefoil (d), hop clover (e), yellow trefoil (f), bird's-foot trefoil (g), wild geraniums (h, i, and j), spiny sida (m), evening primrose (n), red pimpernel (o), sticktight (p), vervain (r); (fig. 21) catmint (a), healall (b), rough-leaved toadflax (c), smaller broad-leaved plaintain (d), bracted plantain (e), field madder (g), cleavers (h), wild corn salad (i and j), poverty weed (k), dog fennel (m), field camomile (n), scentless camomile (o), cornflower (p), cat's-ear (q), oxtongue (r), hawkweed picris (s).

The bulk of the domestic alfalfa seed is produced in the Western States and many kinds of weed seeds it carries are distinctly different from those appearing in imported seed. The weed seeds (if not associated with kinds distinctly foreign) pointing decisively to domestic production are: (Fig. 17) sand bur (a), Russian thistle (h), cow cockle (i) fragments; (Fig. 18) tumbling mustard (c), small-seeded alfalfa dodder (h), the form of field dodder (i) having light-colored seeds, large-seeded alfalfa dodder (j), ragweed (n), gumweed (o), wild sunflower (p); (fig. 19) wild saltbush (m), spreading amaranth (o); (fig. 20) spiny sida (m); and (fig. 21) poverty weed (k).

European origin of alfalfa is indicated by the presence of the following weed seeds: (Fig. 17, white campion (j); (fig. 18) wild carrot (d), clover dodder (g), wild chicory (t); (fig. 19) wild spurry (p), chickweed (q), forked catchfly (t); (fig. 20) creeping buttercup (a), bird's-foot trefoil (g), wild geraniums (h, i, and j), red pimpernel (o), vervain (r); (fig. 21) rough-leaved toadflax (c), field madder (g), wild corn salad (i and j), scentless camomile (o), oxtongue (r), hawkweed picris (s).

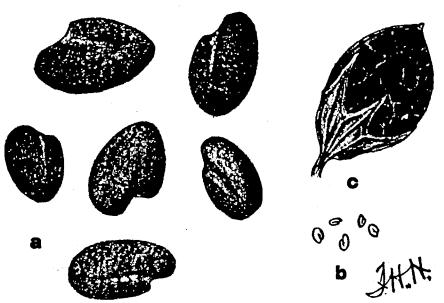

FIG. 27.—Seeds of sweet clover: a, Seeds showing variation in form and size; b, natural size of seeds; c, a pod of sweet clover.

TESTING ORCHARD GRASS SEED.

Orchard grass seed should be carefully mixed before the test sample is taken, because small and relatively heavier impurities are likely to settle to the bottom of the bulk sample. Seed equal to the weight of 12½ BB shots may be taken for the test sample.

Orchard grass seed is readily identified by the slender, pointed form of the seed in the chaff. The lemma of the seed is angled on the back and is curved to one side toward the pointed apex (fig. 10, a). The seeds are three-eighths inch to one-half inch long. Some of the seeds bear the sterile chaff of a second seed (middle of fig. 10, a).

Orchard grass seed is adulterated by the use of English rye-grass seed, meadow fescue seed, and orchard grass chaff. The seeds of meadow fescue (fig. 10, b) and of English rye-grass (fig. 10, c) are very similar. They are about the same length as the orchard grass seeds, but are flattened and broader, not curved nor slender pointed. When seen under a magnifier the two kinds may be distinguished by the difference between the rachilla segments, that of meadow fescue being slender, cylindrical, and distinctly expanded at the apex; that of English rye-grass usually wedge shaped, flattened, and scarcely expanded at the apex (fig. 11, b and c). Both of these kinds of seed often appear as adulterants of the same lot of orchard grass seed. Orchard grass chaff may be distinguished by its light weight, sometimes to some extent by its light color and by the absence of a grain as observed by pressure.

If in making a practical test of orchard grass seed the empty, chaffy seeds freed from other chaffy material are separated from among the grain-bearing seeds the labor is greatly increased. Such chaffy seeds may better be left with the grain-bearing seeds and indiscriminately counted for the germination test, in which the true value will appear. This test requires fourteen days. New, well-cleaned seed should germinate 95 to 98 per cent. The purity should be 98 or 99 per cent.

The noxious weed seeds found in orchard grass include: (Fig. 17) wild oat (**b**), chess (**c**), dock (**f**), including the chaffy covering, black bindweed (**g**), bladder campion (**k**), field peppergrass (**o**); (fig. 18) tumbling mustard (**c**), rat-tail plantain (**l**), buckhorn (**m**), oxeye daisy (**q**).

Other weed seeds commonly found in orchard grass seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), velvet grass (**e**), soft chess (**f**), sedge (**g**), sorrel (**h**), lamb's-quarters (**l**), rough amaranth (**n**); (fig. 20) creeping buttercup (**a**), peppergrass (**b**), wild geranium (**i**); (fig. 21) field madder (**g**), cleavers (**h**), scentless camomile (**o**), cat's-ear (**q**).

TESTING MEADOW FESCUE SEED.

Individual meadow fescue seeds are boat-shaped, three-eighths inch to one-half inch long, flattened; the lemma rounded, its apex rather bluntly pointed. The characteristic rachilla segment is slender, cylindrical, and distinctly expanded at the apex (fig. 10, **b**; fig. 11, **b**).

Meadow fescue is often adulterated with seed of English rye-grass, which is almost identical in form but may be distinguished by the rachilla segment which is usually wedge shaped, flattened, and scarcely expanded at the apex (fig. 10, **c**; fig. 11, **c**). The examination of meadow fescue seed for English rye-grass as an adulterant should always be made. The extent of the adulteration may be determined by count from 1,000 seeds of the mixture as previously described.

The seed of chess (fig. 11, **d**) has been used as an adulterant of meadow fescue seed. The chess seeds are larger, usually cylindrically folded, and sometimes have a short awn at the apex. The rachilla segment is curved and club shaped.

Meadow fescue seed usually is comparatively free from meadow fescue chaff, but very poor seed may contain chaff of orchard grass or worthless orchard grass seed. The purity should reach 99 per cent, the viability 95 to 98 per cent.

The noxious weed seeds found in meadow fescue seed include; (Fig. 17) chess (**c**), quack-grass (**e**), dock (**f**), bladder campion (**k**), field peppergrass (**o**), small-fruited false flax (**q**), English charlock (**t**); and buckhorn (fig. 18, **m**).

Other weed seeds found in meadow fescue seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), velvet grass (**e**), soft chess (**f**), sedge (**g**), sorrel (**h**), lady's-thumb (**k**), lamb's-quarters (**l**), wild spurry (**p**); (fig. 20) creeping buttercup (**a**), peppergrass (**b**), yellow trefoil (**f**), forget-me-not (**q**); (fig. 21) bracted plantain (**e**), field madder (**g**), cat's-ear (**q**), hawkweed (**t**).

TESTING TIMOTHY SEED.

Timothy seed is, as a rule, very pure and not subject to adulteration other than by the use of old seed. Tests of this seed are easily made.

After thorough mixing, a quantity of seed equaling the weight of 6¼ BB shots, at least, should be taken for the test sample. Timothy seed is readily identified (fig. 28). It appears both in the chaff (**a**) and as free grains (**b**). Seed in the chaff should have a silvery-white

appearance. Free grains are slightly darker and dull. If they are brown a damaged condition is suggested. The purity should be 99 per cent or higher; the viability 98 or 99 per cent. The germination test requires five or six days. In addition to the weed seeds found in timothy some lots contain Kentucky bluegrass seed and Canada bluegrass seed (fig. 9) and alsike clover seed (fig. 24).

The noxious weed seeds found in timothy include: (Fig. 17) dock (**f**), bladder campion (**k**), night-flowering catchfly (**l**), small-fruited false flax (**q**); (fig. 18) rat-tail plantain (**l**), buckhorn (**m**), Canada thistle (**r**). European timothy seed is said to sometimes contain clover dodder (fig. 18, **g**), probably due to its being grown with dodder-infested clover. This dodder does not occur in American or Canadian timothy seed. The most serious impurity is Canada thistle seed found in Canadian-grown timothy.

Other weed seeds occurring in timothy seed include: (Fig. 19) witch-grass (**b**), yellow foxtail (**c**), green foxtail (**d**), sedge (**g**), sorrel (**h**), lady's-thumb (**k**), lamb's-quarters (**l**), mouse-ear chickweed (**s**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**), yellow trefoil (**f**), evening primrose (**n**); (fig. 21) catmint (**a**), smaller broad-leaved plantain (**d**), dog fennel (**m**), field camomile (**n**).

TESTING KENTUCKY BLUEGRASS SEED.

The Kentucky bluegrass seed in the American market is produced in this country, chiefly in Kentucky. Seed in bulk has a brownish-straw color. Individual seeds are canoe shaped, approximately three thirty-seconds of an inch long, the back of the lemma being sharply angled. A slender ridge on each side of the angle of the lemma is usually evident (fig. 9, **a**).

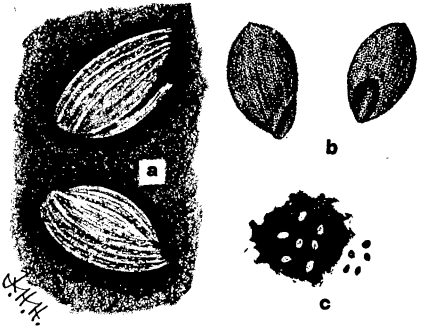

FIG. 28.—Seeds of timothy: **a**, Grains in the hull, or chaff; **b**, grains removed from the chaff; **c**, the same, natural size.

The chief points to be considered in testing Kentucky bluegrass seed are the presence of Canada bluegrass seed as an adulterant and the presence of an undue amount of chaff or of dead seed.

Canada bluegrass seed has been employed in large quantities as an adulterant of or a substitute for Kentucky bluegrass seed. Its seed is very similar to the latter, but can be distinguished by means of a magnifier. In general Canada bluegrass seed in bulk has a somewhat lighter color. Its individual seeds (fig. 9, **b**) are broader, more blunt and papery at the apex, and the sides of the lemma are devoid of the ridges which are distinct in seeds of Kentucky bluegrass seeds (fig. 9, **a** and **b**; fig. 16). The extent of adulteration is determined from 1,000 seeds of the mixture counted indiscriminately.

Since it is difficult to remove all the sterile chaff from seeds containing a grain, it will suffice in making practical tests to remove the lightest chaff, pieces of stems, leaves, etc., as inert matter, endeavoring to leave all the grain-bearing seeds with the pure seed, which by this method will contain also some empty, or sterile, seeds. The pure seed and chaff are separated by placing the weighed sample, a little at a time, on a smooth cardboard tray and pouring it into another tray, allowing the seeds to roll across the face of the tray. The light chaff is held

behind, while the heavier grain-bearing seeds roll off. Carefully repeating the operation two or three times effects a very satisfactory separation. After removing the foreign seeds, the seeds (200 in duplicate) for the germination test are to be counted out from the "pure seed" separation, the chaffy and grain-bearing seeds being taken indiscriminately.

Kentucky bluegrass seed should be comparatively free from chaff, but the methods of cleaning in use leave from 10 to 20 per cent or more of chaff with the pure seed. Some samples show the purity ranging from 80 to 85 per cent, but most tests range from 70 to 80 per cent and many fall much lower. The viability ranges from 80 to 90 per cent in the best samples, but most tests range from 65 to 80 per cent and many fall lower. The method of making the purity test given here tends to give higher purity and lower viability than more carefully made official tests. The most of the sprouts appear within nine or ten days, others appearing from time to time until the twenty-eighth day. Only a very light covering, if any, should be placed over the seeds. It is better that they remain uncovered on the cloth or paper if the inverted dish keeps the air about the seeds moist.

The noxious weed seeds found in Kentucky bluegrass seed include: (Fig. 17) dock (**f**), small-fruited false flax (**q**); (fig. 18) corn gromwell (**k**), rat-tail plantain (**l**), buckhorn (**m**), also Canada thistle (**r**) when mixed with Canada bluegrass.

Other weed seeds found in Kentucky bluegrass seed include: (Fig. 19) sedge (**g**), sorrel (**h**), lamb's-quarters (**l**), mouse-ear chickweed (**s**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**); (fig. 21) dog fennel (**m**), cat's-ear (**q**), hawkweed (**t**).

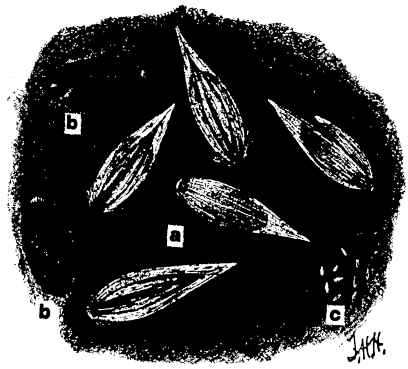

FIG. 29.—Seeds of redtop representing the "fancy" (or "solid") grade of the trade: **a**, Different views of seeds having the white, papery, inner chaff; **b**, two views of a grain, or kernel, with the inner chaff removed; **c**, the same, natural size.

TESTING REDTOP SEED.

In testing redtop seed it should be borne in mind that three grades of this seed are offered in the trade under the names (1) "recleaned" or "solid" seed, (2) "unhulled," and (3) "chaff" seed. The application of these terms becomes evident when the structure of the seed is considered. The recleaned or solid seed consists (fig. 29) of a mixture of free grains (**b**) and grains covered by the silvery, papery inner chaff (**a**). This is the best matured, purest, and heaviest of the grades of redtop. The unhulled grade consists chiefly of seed inclosed in the outer chaff (fig. 30, **a**). This seed is generally more immature than the first grade. It also is lighter and lower in purity than the other. Chaff redtop is a very variable grade consisting largely or almost entirely of empty chaff scales (fig. 30, **a** and **b**) and pieces of stems, leaves, and other inert materials. Many samples of chaff redtop contain very little solid seed.

The recleaned grade is usually comparatively free from impurities, but sometimes contains timothy to the extent of severe adulteration and so should be tested in this respect.

In making a practical test of the unhulled and chaff grades of redtop the lightest chaff may be blown carefully from the heaviest seed of a quantity of seed of known weight. Some seeds will retain the inclosing outer chaff, giving them the appearance shown in figure 30, **a**. Slight rubbing will loosen this outer chaff, when it, too, may be blown away, leaving the pure seed in essentially the same condition as shown in the recleaned grade. This seed, after removing the ergot, timothy, and other foreign seeds, may then be weighed and its quantity compared with the quantity of the original test sample. Such a comparison sometimes shows a surprisingly small quantity of true seed in chaffy grades.

The purity of commercial redtop seed is evidently dependent on the trade grade and the extent to which the grades are cleaned. The solid or recleaned grade should show a purity of 95 to 98 per cent. The germination should be as high. The unhulled grade is more variable both as to purity and viability. The purity is influenced by the widely variable quantity of broken leaves, ergot, and loose chaff, and the viability varies because of the practically worthless immature and undeveloped grains which constitute a variable proportion of this grade of seed.

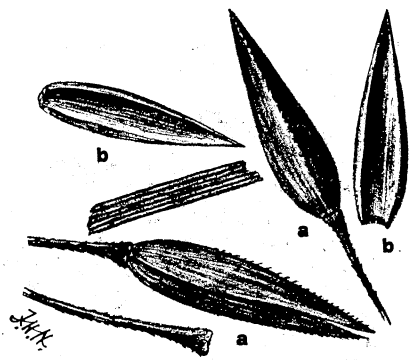

FIG. 30.—Chaff of redtop seed: **a**, Whole spikelets usually devoid of seed in "chaffy" grades; **b**, separated scales of the same; **a** and **b** represent the outer chaff of the seed. (Enlarged.)

The noxious weed seeds found in redtop (chiefly in the chaffy grades, include: (Fig. 17) dock (**f**); (fig. 18) tumbling mustard (**c**), rat-tail plantain (**l**), buckhorn (**m**), oxeye daisy (**q**).

The commoner of the other weed seeds found in redtop seed include: (Fig. 19) crab-grass (**a**), witch-grass (**b**), sedge (**g**), lamb's-quarters (**i**), chickweed (**r**); (fig. 20) peppergrass (**b**), shepherd's purse (**c**), cinquefoil (**d**); (fig. 21) black-eyed Susan (**l**), dog fennel (**m**), field camomile (**n**).

TESTING AWNLESS BROME-GRASS SEED.

Both domestic and imported seed of awnless brome-grass (*Bromus inermis*) is in the American market. This seed should be readily recognized by its large size and thin, boat-shaped form and the light-brown color of the individual seeds. The large, thin, dark-brown grain of the seed is easily distinguished through the papery palea (fig. 11, **a**).

Adulteration of awnless brome-grass seed consists in the use of seed of meadow fescue and of English rye-grass (fig. 11, **b** and **c**.) The seed of chess, or cheat, sometimes passes in the trade as awnless brome-grass seed. These two kinds of seed are closely related botanically, but they are readily distinguishable under careful observation (fig. 11, **a** and **d**).

One objection to the use of brome-grass seed imported from Europe is that it carries the seed of quack-grass (fig. 17, **e**). Unfortunately in respect to popular seed testing, awnless brome-grass seed produced in the Northwestern States and in Canada may carry seed

of wheat-grass which is so similar to that of quack-grass that the layman is not likely to distinguish them with certainty.[a]

The number of kinds of weed seeds carried by awnless brome-grass seed is comparatively small, but some of them are very undesirable.

Awnless brome-grass seed should show purity of 98 or 99 per cent and viability of 90 to 95 per cent in fourteen days.

The noxious weed seeds found in this seed include: (Fig. 17) wild oat (**b**), chess (**c**), quack-grass (**e**), black bindweed (**g**), pennycress (**n**), field peppergrass (**o**), large-fruited false flax (**p**); and field bindweed (fig. 18, **e**).

Other weed seeds sometimes appearing in awnless brome-grass seed include: (Fig. 19) soft chess (**f**), lady's-thumb (**k**), lamb's-quarters (**l**), rough amaranth (**n**); (fig. 20) yellow trefoil (**f**), sticktight (**p**); and cleavers (fig. 21, **h**).

European origin of awnless brome-grass seed is strongly suggested by the presence of seeds of quack-grass (fig. 17, **e**), false flax (fig. 17, **p**), field bindweed (fig. 18, **e**), and soft chess (fig. 19, **f**).

TESTING SEED OF MILLETS.

The millets used as forage crops in this country represent three distinct kinds of grasses—the broom-corn, or grain, millets (fig. 31, **a**), the foxtail millets (German, common, and Hungarian; fig.

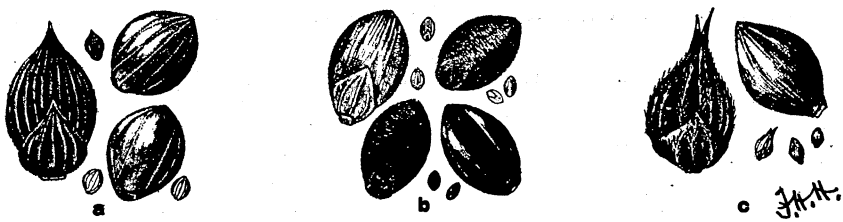

FIG. 31.—Seeds representing the three groups of millets: **a**, Broom-corn millet; **b**, foxtail millets, including the German, common, and Hungarian varieties; **c**, barnyard and Japanese millets. (Enlarged and natural size.)

31, **b**), and the barnyard and Japanese millets (fig. 31, **c**). The seed test should show which kind is involved.

Seeds of the broom-corn millets (fig. 31, **a**) are mostly free from the brown, papery, loose-fitting chaff; they are broadly oval, robust, highly polished, shining, and tend to roll readily on a plane surface. The color varies in different varieties and includes straw-color, light yellow, orange, gray, and dark brown.

Seed of the foxtail millets (fig. 31, **b**) appears both with and without the thin, whitish, outer chaff, most of the seeds being free from it. With the outer chaff removed, the seeds present a finely roughened, or stippled, surface which has a slight luster. German millet seeds usually are broadly oval, robust; they roll readily and are commonly orange colored. Common millet seeds are oval, but relatively longer in proportion to their width than seeds of German millet; yellowish or greenish in color. Hungarian millet seed consists of a mixture of yellow or golden colored seeds and of dark-purple seeds. The darker seeds are often mottled. Seeds of the foxtail millets, particularly those of common millet, are distinguish-

[a] Circular No. 73 of the Bureau of Plant Industry points out the distinguishing characters of the seeds of quack-grass, slender wheat-grass, and western wheat-grass.

able from the similar seeds of the weed, green foxtail (fig. 19, d), by their slightly larger size and more polished surface.

Seed of barnyard millet including that of Japanese millet (fig. 31, c) is chiefly inclosed in the light-brown or dark-brown, hairy, sharp-pointed outer chaff. With this chaff removed, the seed is oval, whitish or gray, smooth, and polished, plano-convex, the convex face strongly arched (fig. 31, c).

The purity of all the millets should reach 99 per cent, the viability 95 per cent or higher in three to five days.

Much of the seed of all the millets used in this country, excepting possibly the common barnyard millet, is imported, and many kinds of injurious weeds are thus introduced. This is particularly true of the broom-corn and foxtail millets. About the same kinds of weed seeds are carried by each.

The noxious weed seeds found in broom-corn millet include: (Fig. 17) dock (f), black bindweed (g), corn cockle (i), night-flowering catchfly (l), cow cockle (m), pennycress (n), ball mustard (r), English charlock (t); (fig. 18) Indian mustard (a), hare's-ear mustard (b), tumbling mustard (c), field bindweed (e), corn gromwell (k), rat-tail plantain (l), buckhorn (m), wild sunflower (p), Canada thistle (r), wild chicory (t).

Other weed seeds commonly found in broom-corn millet include: (Fig. 19) crab-grass (a), yellow foxtail (c), green foxtail (d), soft chess (f), sorrel (h), knotweed (i), pale knotweed (j), lady's-thumb (k), lamb's-quarters (l), rough amaranth (n), spreading amaranth (o), wild spurry (p); (fig. 20) creeping buttercup (a), red pimpernel (o), sticktight (p), vervain (r); (fig. 21) healall (b), cleavers (h), dog fennel (m), field camomile (n).

TESTING SEED WHEAT.

A practical test of seed wheat may be made in which the points to be considered are the quantity of shriveled, or "pinched," grains, the presence of bunt, the quantity and character of the weed seeds, and the viability of the plump grains.

After thorough mixing of the bulk sample, a quantity of seed equaling the weight of 12½ or even 25 BB shots may be taken for the test sample. This should be separated into plump, well-filled, large grains and shriveled, small grains.

While making this separation the presence or absence of bunt, or diseased grains, should be noted. Such grains are somewhat above the average size of the best grains, brown in color, soft, and show a blackened interior when broken open. Seed fit for sowing should be plump and well filled; it should show at least 99 per cent purity and 99 per cent viability in three days and be free from bunt.

The noxious weed seeds found in wheat include: (Fig. 17) wild oat (b), chess (c), darnel (d), quack-grass (e), dock (f), black bindweed (g), Russian thistle (h), corn cockle (i), cow cockle (m), pennycress (n), field peppergrass (o), false flax (p), ball mustard (r), black mustard (s), English charlock (t); (fig. 18) Indian mustard (a), hare's-ear mustard (b), tumbling mustard (c), field bindweed (e), corn gromwell (k), ragweed (n), the similar (but larger) seeds of giant ragweed, wild sunflower (p), Canada thistle (r), bull thistle (s), and the whitish or pinkish bulblets of wild garlic which are sometimes very abundant in wheat grown in the Eastern States.

Other weed seeds occurring in wheat include many of those found in forage-crop seeds. This is particularly true of wheat which has been poorly cleaned.

A test of a poor grade of wheat along the lines suggested should convince any farmer of the value of the fanning mills and suitable screens used in grading seed wheat.

TESTING SEED OATS AND BARLEY.

Seed of oats and barley may be tested in general as outlined for wheat. In testing oats especial attention should be given to the possible presence of seed of wild oat (fig. 17, **b**), which can be recognized by its brown color, the brown hairs at the base of the seed, the bent awn at the back, and especially by the expanded, cup-shaped scar at the base of the seed.

The purity of oats and barley should reach 99 per cent, the viability at least 95 per cent for oats and 98 or 99 per cent for barley.

In general the weed seeds appearing in wheat may be expected to appear in poorly cleaned oats and barley.

TESTING FLAX SEED.

Properly cleaned flax seed should be practically free from impurities, thus showing a purity of nearly 100 per cent. The viability should reach 99 per cent or higher in two or three days. Both domestic and imported seed are in the market. Poorly cleaned grades contain many kinds of weed seeds which, in general, include most of those found in millet seed and in wheat. In a test of flax seed especial attention should be given to the discovery of seed of flax dodder. As shown in figure 12, some of these dodder seeds are double and thus fail to pass a sieve which will remove most of the single seeds. Fairly well-cleaned lots of flax seed are thus likely to contain these double seeds of dodder. Much of the imported flax seed contains seed of flax dodder. The very destructive nature of this dodder justifies every effort to prevent the introduction of its seed. Seed of false flax (fig. 17, **p**) is a common noxious impurity which should be avoided.

TESTING WINTER RAPE SEED.

Popular tests of rape seed are not likely to be wholly satisfactory because of the difficulty in identifying with certainty the seeds of the different kinds of rape and the closely allied mustard weeds. Seed of the more important winter, or Essex, rape may generally be recognized by the relatively large size of the individual seeds (somewhat larger than those of summer rape or of turnip), by their steel-black color, and their roundness, allowing them to roll readily on a plane surface. Summer rape seeds are mostly smaller, consisting of a mixture of black and reddish seeds, some of the black seeds being distinctly pitted, or nearly all the seeds reddish. Some lots of seed, particularly of summer rape, are adulterated with seed of English charlock (fig. 17, **t**). As a rule the charlock seeds may be distinguished by their smaller size, more nearly spherical form, their smoother surface and by the presence of mature reddish or brown seeds with the black ones. Some lots of rape seed are heavily adulterated with seed of Indian mustard (fig. 18, **a**). These seeds are readily recognized by their uniformly reddish-brown color and by the netted or pitted surface as seen under a magnifier. The purity of winter rape should be 99 per cent or higher, the viability as high under a test of two or three days' duration. A miscellaneous series of weed seeds, most of which are previously described and figured, is likely to appear in poorly cleaned grades of rape seed, particularly the summer variety.

TESTING VETCH SEED.

A popular test of vetch seed consists chiefly in distinguishing the seed of hairy (winter) vetch and that of spring vetch, and determining the viability.

Winter vetch seed (fig. 32, **a**) consists of nearly spherical, steel-black seeds showing some variation in size. The seed is distinguished from other kinds by its characteristic seed-scar which is oblong-oval with a whitish slit through the center. A small protuberance (the chalaza) of the seed coat is located nearly the length of the scar distant from the narrower end of the scar, as shown in the figure.

Seeds of spring vetch represent several varieties and thus are variable in size, form, and surface. The characteristic scar is wedge shaped with a slender, black slit through its center, the slightly raised margins of the slit usually being light colored. The usually distinct chalaza, as a rule, is about half the length of the scar distant from the narrower end of the scar (fig. 32, **b**). Some seeds of spring vetch are large, compressed, and somewhat angular; others are nearly spherical and smaller. The surface is black, brown, gray, or mottled. In one variety, a common impurity of winter vetch seed, the seeds are spherical, jet-black, and about the size of the smaller winter vetch

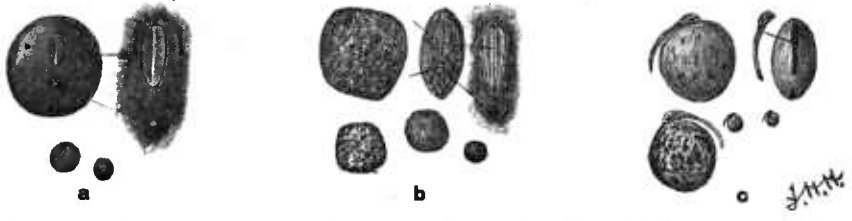

FIG. 32. Seeds of three kinds of vetch; **a**, Winter (or hairy) vetch; **b**, spring vetch; **c**, wild vetch (*Vicia hirsuta*). (Enlarged and natural size.)

seeds. Only careful examination under a magnifier discloses their darker color and characteristic scar in which, however, the margins of the scar slit are black. In testing seed of winter vetch the seeds of this variety of spring vetch should be sought especially. Seeds of other varieties of spring vetch are usually distinguishable from winter vetch seeds by their different form or color.

Various weed seeds, mostly of the class appearing in seed of millets and cereal grains, are sometimes present in poorly cleaned vetch seed. The seed of a wild species of vetch (*Vicia hirsuta* (L.) Koch, fig. 32, **c**) is a common impurity of cultivated vetch seed.

Vetch seed should show nearly 100 per cent purity. The viability of commercial seed is variable and is strongly influenced by the hard seed, especially in the case of winter vetch in which the hard seed may amount to 30 per cent or more. In spring vetch the hard seed usually varies between 5 and 15 per cent. The sprouting of the hard seed is hastened in the test by cutting through the seed coat with a knife blade, thus admitting moisture. The coat should not be cut in the vicinity of the seed scar lest the embryo be injured.

The germinable seed in high-grade lots of commercial winter vetch seed, together with the variable quantity of hard seed, ranges from

95 to 98 per cent. Some lots germinate between the second and sixth days; others during the second week of the test.

In spring vetch viability of 95 to 98 per cent is less commonly reduced by the hard seed. Sprouting takes place chiefly between the third and fifth days.

TESTING SEED CORN.

The testing of seed corn so far as it corresponds to the tests applied to seed of other crops consists chiefly of the germination test, showing how much of the seed will germinate and with what vigor. Assuming that the corn to be used for seed is in the ear and has been selected with reference to variety and in conformity with the recognized type of ear and of kernel best adapted for crop production, it remains to test its viability.

The two types of germinator adapted for this work have already been referred to (p. 14). After removing sufficient of the butt and tip kernels of the ear to leave on the cob kernels of uniform size, 6 kernels are removed for test. Of these, 2 are taken from near the butt, 2 from the middle, and 2 from near the tip. Each pair of kernels should be taken from opposite rows, these rows being one-third of the circumference of the ear apart. In this way fairly representative kernels of the ear are chosen. The kernels are placed side by side, germ side uppermost, in the marked squares of the germinator which are numbered serially, the ears furnishing the kernels for the squares being numbered correspondingly. This is an individual ear test. Every seed should germinate, thus showing viability of 100 per cent. If any of the kernels of an ear fail to germinate, that ear should be discarded. If the germination for any ear is weak, producing inferior sprouts or is unduly slow, the ear should be rejected. The character of the sprouting should be apparent in five days.

SUMMARY.

(1) It is important that farm seeds be tested before they are sown.

(2) Seed testing in its essential features giving practical results can be done more easily than is generally believed.

(3) By means of a seed test the actual value of seed in question as compared with seed of the best quality can be determined and damage to the crop or the land due to noxious weed seeds can be avoided.

(4) Practical seed tests can be made with simple equipment by anyone interested in the purchase or use of seeds.

(5) It is readily possible for the farmer to make practical tests of seeds, thereby safeguarding against partial or complete loss of crops.

(6) Seed testing is admirably adapted for practical exercise work in elementary agriculture in rural schools.

(7) The essential preparation for making seed tests consists of providing the simple apparatus necessary and of becoming familiar with the general purposes and methods of testing and the features of importance peculiar to tests of particular kinds of seeds.

O